METHODS FOR SULFATE AIR QUALITY MANAGEMENT

Volume 3

Appendices

by

Glen R. Cass

with

Pamela S. McMurry and James E. Houseworth

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Environmental Quality Laboratory
California Institute of Technology
Pasadena, California 91125

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Final Report to the

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APPENDIX A

EMISSION SOURCE RELATED APPENDICES

APPENDIX A1

THE QUANTITY AND SULFUR CONTENT OF CRUDE OIL SUPPLIED TO THE SOUTH COAST AIR BASIN IN 1973

A1.1 Introduction

In this appendix, the methods used to trace crude oil from its source to the South Coast Air Basin will be described. The purpose of this study was to assure that the amount of sulfur entering the air basin via crude oil was fully determined. Therefore, a serious attempt was made to find the sulfur content as well as the quantity of the oil delivered. This survey was nominally conducted for the year 1973, although some of the data employed came from other recent years. In the following paragraphs, a brief description of the approach used in this study will be given.

Crude oil quality varies widely from one oil field to another. In order to obtain a quantitative description of crude oil properties entering the South Coast Air Basin, the oil must be tracked to its source. Oil-producing regions of the world were subdivided into three basic categories: California oil fields, other domestic sources, and foreign crude oil supplies. These categories are convenient because different data sources are needed to assess crude oil properties from each of these three producing territories.

Smaller geographic regions within each producing category were then defined. California oil fields were subdivided into five producing regions based on geographic terrain and access to common transportation links. Previously reported surveys of California oil use (Nehring, 1975) showed that the only non-California domestic oil producing regions important to California oil consumption were in Alaska and the Four Corners area between Utah and New Mexico. Foreign crude oils were first considered by country of origin, and then grouped into ten major geographic zones (e.g. South Pacific, Persian Gulf, etc.).

Total oil production in each major field in each producing district was determined for a base year of interest. Then sulfur content information for crude oil from each field was used to compute the total quantity of associated sulfur produced along with the oil. Sulfur and oil production data were then pooled for all fields within the producing district of interest. The distribution of crude oil production within sulfur content intervals was determined. The fraction of oil production with a sulfur content between 0.26% and 0.50% sulfur, for example, was then apparent in any producing district. Finally, a weighted average sulfur content of crude oil was determined for each sulfur content interval in each producing district. In that manner, oil supplies at the wellhead around the world were organized and stratified by sulfur content.

Next, oil shipments to the South Coast Air Basin were estimated by investigating available transportation links. California crude oil shipments to the South Coast Air Basin were estimated from local production within the Los Angeles Basin, plus waterborne commerce data and pipeline capacities.

Crude oil transfers to the entire state of California from out-of-state domestic sources and from major foreign countries were obtained by producing district of origin for 1973. Total receipts of non-California crude oil at local harbors were determined. Unfortunately, these local harbor crude oil receipts are not resolved by state or by country of origin. Therefore, the assumption was made that the distribution of crude oil by country of origin arriving at South Coast Air Basin ports was directly proportional to that estimated for all foreign and out-of-state domestic oils received by ship in California.

By combining crude oils from California fields, out-of-state domestic sources and foreign imports, both the total quantity of crude oil and the distribution of that oil between high sulfur and low sulfur crude oils, was estimated. The details of this crude oil characterization study will now be presented. A discussion of this survey's implications for control of sulfur oxides emissions by manipulation of crude oil entering the South Coast Air Basin will then follow.

A1.2 California Crude Oil

A1.2.1 Characterization of Production by Sulfur Content

Table A1.1 shows the fraction of California oil production appearing within sulfur content intervals as a function of oil field location. Oil production data came from the California Division of Oil and Gas, (1974). Crude oil sulfur content data, given by the Bureau of Mines (1975b), was matched on a field-by-field basis with the state oil production figures. Then, data for all fields within each producing region were totaled. In a few cases, subfields were listed by the Bureau of Mines (1975b) which were not

TABLE A1.1

Characterization of California Crude Oils by Sulfur Content

Producing Region and Sulfur Content Range	Total 1974 Production (thousands of barrels per year)	% of Total Production	Average Weight Percent Sulfur
I. Local Crudes Produced within the South Coast Air Basin (1974)			
A. Los Angeles Basin			
0.00 to 0.25%S	0.0	0.0	---
0.26 to 0.50	1,844.3	1.5	0.44
0.51 to 1.00	13,854.5	11.0	0.73
1.01 to 2.00	96,798.2	77.0	1.48
2.01 to 3.00	11,231.5	8.9	2.41
3.01 to 4.00	1,905.1	1.5	3.08
4.01 and up	49.0	0.0	4.43
L.A. Basin subtotal	125,682.6		1.49
B. Ventura Area (on-shore only)			
0.00 to 0.25%S	0.0	0.0	---
0.26 to 0.50	123.7	0.4	0.40
0.51 to 1.00	4,486.8	16.3	0.82
1.01 to 2.00	18,938.5	68.7	1.10
2.01 to 3.00	2,593.3	9.4	2.75
3.01 to 4.00	497.5	1.8	3.40
4.01 and up	944.4	3.4	4.50
Ventura subtotal	27,584.2		1.08
II. California Crudes Produced Outside of the South Coast Air Basin (1974)			
A. Central California Coast (District 3 minus two fields: 1) Cuyama South Main; 2) Russell Ranch Main)			
0.00 to 0.25%S	52.8	0.2	0.18
0.26 to 0.50	0.0	0.0	---
0.51 to 1.00	35.0	0.1	0.69
1.01 to 2.00	73.7	0.2	1.30
2.01 to 3.00	16,130.9	54.7	2.30
3.01 to 4.00	436.9	1.5	3.66
4.01 and up	12,781.2	43.3	4.70
Central Coast subtotal	29,510.5		3.35
B. San Joaquin Valley - Districts 4 & 5 plus two fields listed above			
0.00 to 0.25%S	11,347.3	9.2	0.21
0.26 to 0.50	12,030.7	9.8	0.32
0.51 to 1.00	67,041.2	54.4	0.81
1.01 to 2.00	32,791.9	26.6	1.20
2.01 to 3.00	0.0	0.0	---
3.01 to 4.00	0.0	0.0	---
4.01 and up	0.0	0.0	---
San Joaquin Valley subtotal	123,211.1		0.8
C. Northern Region subtotal	432.3		---

itemized in the state oil and gas report. In these cases, oil production figures given in the state report were apportioned to subfields appearing in the Bureau of Mines survey in proportion to 1971 production data given by the Bureau of Mines (1975b). Fields appearing in the crude oil sulfur content survey which are now listed as abandoned by the state were excluded from our study.

Next, the year 1973 was chosen as the base year for our study.[1] Total California oil production in each of our producing regions was obtained for that year from the 59th Annual Report of the State Oil and Gas Supervisor (California Division of Oil and Gas, 1973). The oil was subdivided into quantities produced within various sulfur content intervals in proportion to the sulfur content distribution previously calculated for 1974 in Table A1.1. Oil produced from Federal offshore leases in the Ventura and Santa Barbara areas was characterized as having properties similar to onshore production from Ventura County fields appearing in the state oil and gas reports.

API gravity values were estimated for each sulfur content interval in each producing district based on data contained in a state legislative report on the cost of refining California crude oils (Joint Committee on the Public Domain, 1974a). Given an estimate of API gravity, the density, ρ, of the crude oil may be calculated. The relationship is

$$\frac{1178.41}{°\mathrm{API} + 131.5} = \rho\left(\frac{\mathrm{lbs}}{\mathrm{gallon}}\right) \qquad \text{(A1.1)}$$

[1]Our original intent had been to investigate the year 1974, but complete data on foreign crude oil production and shipment could be obtained only for 1973.

Then from the weight of the crude oil produced and the weight percent sulfur involved, one can calculate the total quantity of sulfur contained in each crude petroleum stock.

A1.2.2 California Crude Oil Transportation to the South Coast Air Basin

At this point we have an estimate of crude oil supplies and sulfur content at the wellhead in various locations throughout California. The next step is to determine how much of each crude oil supply is received by South Coast Air Basin refineries. The two principal transportation modes concerned were ships and pipelines.

California crude oil pipeline capacity and/or throughput data for recent years are contained in a state legislature report (Joint Committee on the Public Domain, 1974b). Information given in that report was used to estimate 1973 crude oil shipments along the Ventura to Los Angeles pipeline system, as shown in Table A1.2.

Crude oil transfers by ship from the Ventura area are given in Waterborne Commerce of the United States - 1973 (Corps of Engineers, 1973). In Table A1.3 those shipments to sea are compared to total Ventura plus Federal offshore production in 1973. The difference between production and shipment to sea is almost exactly equal to estimated pipeline flow. Therefore, the transportation modes used to bring Ventura area oils to market seem reasonably well established. Since the pipeline flows were only approximations based in part on 1972 data, it was assumed that the 1239.9 thousand barrel per year transportation discrepancy apparent for 1973 from Table A1.3 should be resolved by

TABLE A1.2

1973 Estimated Crude Oil Shipments by Pipeline from the Ventura Area to Los Angeles

Operator(c)	Barrels per Day	
Shell Oil	44,915	(a)
Union Oil	32,343	(a)
Texaco	9,450	(b)
	86,708	

Notes:

(a) Based on 1972 throughput data which are assumed to represent 1973 reasonably well.

(b) Enters Los Angeles through merger with pipelines from the San Joaquin Valley.

(c) Mobil Oil also operates a pipeline which connects with Shell and Texaco lines before entering Los Angeles

TABLE A1.3

Transportation Balance on Ventura and Federal Offshore Crude Oils Produced in 1973

	Thousands of Barrels/Year	
	Input	Output
Production	47,090	
Shipped to Sea		14,201.7
Transferred by Pipeline		31,648.4
Totals	47,090	45,850.1

Difference $\left(\frac{\text{In-Out}}{\text{In}} \right) = 2.6\%$

increasing estimated pipeline shipment to South Coast Air Basin refineries by an equivalent amount.

Pipelines leave the San Joaquin Valley oil fields in three directions. One link runs south to Los Angeles. Estimates of flows from the San Joaquin Valley to Los Angeles by pipeline are given in Table A1.4. A second link crosses the coastal mountain ranges and terminates on the central California coast near Estero Bay. The third system of pipelines runs north to the San Francisco Bay.

It is very difficult to estimate the destination of oil shipped through the pipelines running west from the San Joaquin Valley to the central California coast based on publicly available data. These pipelines service two of our producing districts: the San Joaquin Valley and the central California coastal oil fields. Some of the oil in these pipelines is sent to central California refineries and some is shipped to sea. The assumption was made that this pipeline network was the only means of transporting crude oil from central California coastal oil fields to market. Therefore, all central California coastal oil production was fed into this pipeline system. It was then assumed that the remaining pipeline capacity was used to ship oil from the coast to the San Joaquin Valley, or vice versa. Based on these two asusmptions, the utilization of pipelines from the San Joaquin Valley to the central California coast would appear as in Table A1.5.

The next step is to make an estimate of the portion of those domestic crude oils which are shipped to sea that later arrive by tanker in the Los Angeles area. Total domestic crude oil receipts

TABLE A1.4

1973 Estimated Crude Oil Shipments by Pipeline from the San Joaquin Valley to Los Angeles

Operator	Barrels/Day	
Mobil	(+) 52,242	
ARCO	(+) 51,300	(a)
Texaco	(-) 9,450	(b)
	(+) 94,092	

Notes:

(a) The ARCO data on oil shipped is estimated from the size of their pipeline and the relationship between pipeline size and throughput apparent from data furnished by other oil companies who gave both pipeline size, rated capacity, and actual utilization of capacity.

(b) The negative flow shown for Texaco reflects a subtraction from San Joaquin Valley oil transfer capacity to allow for the oil shipped by Texaco from the Ventura area which enters the Los Angeles area via the above San Joaquin Valley pipeline system (see Table A1.2, note (b)).

TABLE A1.5

1973 Estimated Utilization of San Joaquin Valley to Central California Coast Pipelines

Step 1. Determine Pipeline Flow:

Operator	Barrels/Day		Thousand Barrels/Year[b]
Standard Oil	69,518	(a)	25,374.1
Union Oil	55,556	(a)	20,277.9
Total	125,074		45,652.0

Step 2. Estimate Deliveries Beyond the Needs of Coastal California Oil Fields Production:

	Thousand Barrels/Year
Pipeline Use	45,652.0
1973 Coastal California Production	29,595.5
Excess Capacity Used for Shipment of Oil Originating Outside of Central California Coastal Region	16,056.5

Step 3. Assume that the remaining 16,056.5 thousand barrels per year of crude oil shipped through these pipelines represents a transfer of oil between the San Joaquin Valley and coastal ports. The direction of flow is not known for certain.

Notes:

(a) based on 1972 data

(b) based on a 365 day year

at South Coast Air Basin harbors are given by the Corps of Engineers (1973). At several small harbors in the basin, the data available in that publication do not indicate whether crude oil transiting the port is coming in or going out. In those cases, it was assumed that crude oil was received at El Segundo and shipped to sea from Carpenteria, Huntington Beach, Ventura and Port Hueneme. On that basis, total South Coast Air Basin domestic crude oil receipts by tanker are estimated at 54,213 thousand barrels for the year 1973.

Total California refinery domestic crude oil receipts by barge and tanker for that year were 92,935 thousand barrels (Bureau of Mines, 1975a). Thus the South Coast Air Basin appears to have received 58.3% of the domestic crude oil in waterborne commerce off the California coast. The origin of the oil entering local harbors is not known explicitly. Therefore, we will first create a pool of domestic oil that is likely to be in waterborne commerce off the California coast. Then a representative cross section of 58.3% of that oil will be brought into South Coast Air Basin refineries, a quantity sufficient to match total domestic crude oil port receipts.

From our previous discussions, it is clear that 14,201.7 thousand barrels per year of crude oil with Ventura area characteristics is shipped to market by sea. Likewise, waterborne commerce data (Corps of Engineers, 1973) show a transshipment of 9,567.9 thousand barrels per year of Los Angeles Basin crude oil by tanker. Crude oil received in California from Alaska amounted to 46,200 thousand barrels per year in 1973 (Nehring, 1975). These known sources of tanker shipments account for 69,969.6 thousand barrels per year of the 92,935 thousand barrels of domestic oil sought to form our California coastal commerce pool. The remaining shipments to sea came either from the San Francisco area or from the pipelines terminating at ports along the central California coast. Actual crude oil shipments from central California coastal ports cannot be determined precisely. That is because the commerce data at those ports do not indicate whether the oil listed as transiting the port is coming in or going out.

Therefore, some assumptions will be made. It will be assumed that San Francisco, like Los Angeles, is a net sink for crude oil and that crude oil shipments from San Francisco are small. Therefore, the 22,965.4 thousand barrels per year needed to complete the domestic oil shipments received by tanker by California refineries will be taken from the more than ample supply of oil flowing in the San Joaquin Valley to central California coast pipelines. Only 50.3% of the flow in that pipeline system need be placed aboard tankers in order to meet this 22,965.4 thousand barrel per year flow requirement.

The characterization of the source of domestic crude oils received by tanker along the California coast is now complete. Of the 92,935 thousand barrels of domestic oil at sea, a representative cross section of 54,213 thousand barrels (58.3% of the total) was characterized as entering South Coast Air Basin ports in 1973. Pipeline data were then combined with the California oils received by ship. The resulting estimates of California crude oil receipts by South Coast Air Basin refineries are shown in Table A1.6. The sulfur content of non-California domestic crude oils will be discussed next.

TABLE A1.6

1973 South Coast Air Basin California Crude Oil Receipts by Sulfur Content Based on
1974 Production Weighted Average Sulfur Content Data

Producing Region and Sulfur Content Range	1973 Total Production (1000's barrels)	Percent of Production (1974)	Estimated Quantity Produced in 1973 (1000's barrels)	Average Percent Sulfur by Weight	1973 + Estimated Quantity Received in SCAB (1000's barrels)	Approximate Quantity of Sulfur Contained (1000's lbs/year)	Density (pounds per barrel)
I. Local Crudes Produced within the South Coast Air Basin							
A. Los Angeles Basin	132,194.4			1.49	128,207.9*	613,878.5	319.81
	API°						
0.00 to 0.25%S	---	0.0	0.0	---	0.0	0.0	---
0.26 to 0.50	30.1	1.5	1,939.9	0.44	1,881.4	2,534.6	306.18
0.51 to 1.00	29.3	11.0	14,572.3	0.73	14,132.8	31,761.7	307.86
1.01 to 2.00	22.5	77.0	101,813.5	1.48	98,743.2	469,547.6	321.30
2.01 to 3.00	21.0	8.9	11,813.4	2.41	11,457.2	89,644.6	324.66
3.01 to 4.00	19.2	1.5	2,003.8	3.08	1,943.4	19,659.3	328.44
4.01 and up	18.3	0.0	51.5	4.43	49.9	730.7	330.54
B. Ventura and Fed. offshore	47,090.0			1.36	41,172.8**	176,503.9	310.45
	API°						
0.00 to 0.25%S	---	0.0	0.0	---	0.0	0.0	---
0.26 to 0.50	35.2	0.4	188.4	0.40	164.7	195.6	296.94
0.51 to 1.00	31.2	16.3	7,675.7	0.82	6,711.2	16,734.1	304.08
1.01 to 2.00	28.6	68.7	32,350.8	1.10	28,285.7	96,180.4	309.12
2.01 to 3.00	23.6	9.4	4,426.5	2.75	3,870.2	33,972.6	319.20
3.01 to 4.00	19.6	1.8	847.6	3.40	741.1	8,254.7	327.60
4.01 and up	15.8	3.4	1,601.1	4.50	1,399.9	21,166.5	336.00

+ Based on receipt of 54,213 thousand barrels of domestic oil by sea. The remainder either came by pipeline or was produced in the L. A. Basin.

*122,626.5 thousand barrels stay in the L.A. Basin. 9,567.9 thousand barrels are shipped to sea. The South Coast Air Basin is then estimated to receive 58.3% of all domestic oil shipped in California commerce.

** 32,888.3 thousand barrels are piped to South Coast Air Basin refineries. 14,201.7 thousand barrels are shipped to sea. The South Coast Air Basin then estimated to receive 58.3% of all domestic oil shipped in California commerce.

TABLE A1.6 (continued)

Producing Region and Sulfur Content Range	1973 Total Production (1000's barrels)	Percent of Production (1974)	Estimated Quantity Produced in 1973 (1000's barrels)	Average Percent Sulfur by Weight	1973 Estimated Quantity Received in SCAB (1000's barrels)	Approximate Quantity of Sulfur Contained (1000's lbs/year)	Density (pounds per barrel)
II. California Crudes Produced Outside of the South Coast Air Basin							
A. District 3 minus two fields: 1. Cuyama South Main 2. Russell Ranch Main	29,595.5			3.35	8,684.9*	99,808.8	343.32
	API°						
0.00 to 0.25%S	33.3	0.2	59.2	0.18	17.4	9.4	300.30
0.26 to 0.50	---	0.0	0.0	---	0.0	0.0	---
0.51 to 1.00	31.2	0.1	29.6	0.69	8.7	18.3	304.08
1.01 to 2.00	28.6	0.2	59.2	1.30	17.4	69.9	309.12
2.01 to 3.00	11.8	54.7	16,188.7	2.30	4,750.6	37,722.2	345.24
3.01 to 4.00	19.6	1.5	443.9	3.66	130.3	1,562.3	327.60
4.01 and up	13.3	43.3	12,814.9	4.70	3,760.6	60,426.7	341.88
B. San Joaquin Valley Districts 4&5 plus two fields named above	126,768.1			0.81	39,055.4+	102,912.4	319.63
	API°						
0.00 to 0.25%S	35.6	9.2	11,662.7	0.21	3,593.1	2,234.2	296.10
0.26 to 0.50	32.2	9.8	12,423.3	0.32	3,827.4	3,703.7	302.40
0.51 to 1.00	25.2	54.4	68,961.8	0.81	21,246.2	54,354.2	315.84
1.01 to 2.00	13.3	26.6	33,720.3	1.20	10,388.7	42,620.3	341.88
2.01 to 3.00	---	0.0	0.0	---	0.0	0.0	---
3.01 to 4.00	---	0.0	0.0	---	0.0	0.0	---
4.01 and up	---	0.0	0.0	---	0.0	0.0	---

* 50.3% of total production is shipped to sea. The South Coast Air Basin then receives 58.3% of all domestic oil shipped to sea in California commerce.

\+ 16,056.5 thousand barrels is in the central California coastal pipeline. 50.3% of this is shipped to sea. The South Coast Air Basin receives 58.3 of all domestic oil shipped to sea in California commerce. An additional 34,343.6 thousand barrels is piped to Los Angeles.

A1.3 Domestic Crude Oils from Outside of California

A1.3.1 Four Corners Area

Utah oil fields were used as the basis for characterizing Four Corners crude oil since most of the oil imported into California from the Four Corners area came from Utah (Nehring, 1975). Total crude oil production for 1973 was obtained from the International Petroleum Encyclopedia (McCaslin, 1974). The relative abundance of crude oils of various sulfur contents was based on data from Sulfur Content of Crude Oils (Bureau of Mines, 1975b). A rough estimate of crude oil API gravity was obtained from McCaslin (1974). Crude oil density was calculated from equation A1.1.

The amount of Four Corners oil delivered to California in 1973 is given by Nehring (1975). All of this oil was assumed to come to the South Coast Air Basin for processing since there is a direct pipeline link from the Four Corners area to Los Angeles. The Bureau of Mines (1975a) gives the amount of oil transferred to California by interstate pipeline. That pipeline flow amounts to approximately 3/4 of the Four Corners oil received. The remainder must have come to California by tank car or truck.

A1.3.2 Alaskan Oil

Oil fields in southern Alaska were the only other important source of domestic oil supplied to California in 1973. The references used to determine total Alaskan oil production, sulfur content and API gravity are the same as described for Four Corners oil.

Nehring (1975) indicates that 46,200 thousand barrels of Alaskan crude oil was received in California in 1973. This oil was previously mentioned when constructing the pool of domestic crude oil in commerce off of the California coast. As before, it is assumed that 58.3% of these coastal shipments arrive in the South Coast Air Basin, in proportion to the fraction of total California domestic crude oil receipts arriving at local ports.

A summary of interstate domestic oil shipments received in the South Coast Air Basin in 1973 is given in Table A1.7.

A1.4 Foreign Crude Oils

A1.4.1 Characterization of Production by Sulfur Content - 1973

In order to describe foreign imports to the South Coast Air Basin, the crude oils from all of the non-Communist oil producing nations were first characterized by sulfur content. Total production, by country, was obtained from the Minerals Yearbook (Bureau of Mines, 1975a). The relative distribution of crude oil production between crude oils of various sulfur contents was computed for major oil fields in each country from 1971 data given in Sulfur Content of Crude Oils (Bureau of Mines, 1975b). The relative distribution of sulfur contents calculated from major oil fields in each country was then applied to all oil production from that country in 1973.

Foreign countries were then combined into ten large geographic groups (e.g., South Pacific, Persian Gulf, etc.). Sulfur content distributions were calculated for each of these ten large geographic

TABLE A1.7

1973 South Coast Air Basin Crude Oil Receipts by Sulfur Content of Non-California Domestic Oils

State and Sulfur Content Range	Estimated Average API (gravity)	Total Production 1973 (1000's barrels)	% of Total Production (1973)	Average % Sulfur by weight (1973)	Imports to California 1973 (1000's barrels)	% Sulfur	Estimated Quantity Received in SCAB (1000's barrels)	Approximate Quantity of Sulfur contained in 1000's lbs/year	Estimated Average Density (lbs/barrel)
Southern Alaska	35.0								297.26
0.00 to 0.25%S		71,954.9	98.5	0.07	45,507.0	0.07	26,546.2	5,523.8	
0.26 to 0.50		0.0	0.0	---	0.0	---	0.0	0.0	
0.51 to 1.00		1,072.4	1.5	0.82	693.0	0.82	404.3	985.5	
1.01 to 2.00		0.0	0.0	---	0.0	---	0.0	0.0	
2.01 to 3.00		0.0	0.0	---	0.0	---	0.0	0.0	
3.01 to 4.00		0.0	0.0	---	0.0	---	0.0	0.0	
4.01 and up		0.0	0.0	---	0.0	---	0.0	0.0	
Southern Alaska subtotal		73,027.3		0.08	46,200.0	0.08	26,950.5+	6,509.3	
Utah (Four Corners)	35.0								297.26
0.00 to 0.25%S		23,501.9	90.4	0.10	10,847.1	0.10	10,847.1	3,224.4	
0.26 to 0.50		0.0	0.0	---	0.0	---	0.0	0.0	
0.51 to 1.00		306.1	1.2	0.82	141.3	0.82	141.3	344.4	
1.01 to 2.00		2,192.1	8.4	1.99	1,011.7	1.99	1,011.7	5,984.7	
2.01 to 3.00		0.0	0.0	---	0.0	---	0.0	0.0	
3.01 to 4.00		0.0	0.0	---	0.0	---	0.0	0.0	
4.01 and up		0.0	0.0	---	0.0	---	0.0	0.0	
Utah subtotal		26,000.1		0.27	12,000.1	0.27	12,000.1*	9,553.5	

+ Based on the estimate that the South Coast Air Basin receives 58.3% of all domestic oil arriving by tanker in California.

* It is assumed that all Four Corners oil imported to California is directed to Los Angeles.

groups. Then any nations in those geographic areas for which sulfur content data was not available were treated as having a sulfur content distribution in their crude oils like that of the geographic region as a whole. API gravity for each crude oil stock was calculated from data given in the International Petroleum Encyclopedia (McCaslin, 1974).

In the case of Ecuadorian crude oil, a different approach was taken to estimate crude oil sulfur content. In 1973, Ecuadorian crude oils formed a significant fraction of the total foreign oil imports to California (California Energy Resources Conservation and Development Commission, 1975). Unfortunately, the sulfur content of crude oils report (Bureau of Mines, 1975b) did not have any information on Ecuadorian crude oil. But another Bureau of Mines publication, Fuel Oils by Sulfur Content (Bureau of Mines, 1976) gave the sulfur content of Ecuadorian residual fuel oil. It looked very similar to Colombian residual fuel oil sulfur content, so it was assumed that Ecuadorian crude oil had a sulfur content similar to that of Colombian crude oil. Colombian crude oil was listed in Sulfur Content of Crude Oils (Bureau of Mines, 1975b) and had a weighted average of 0.95% sulfur. Therefore, a 1% sulfur content for Ecuadorian crude oil was assumed.

A1.4.2 Foreign Crude Oil Transportation to the South Coast Air Basin

Most of the foreign crude oil received in California in 1973 was identified by country of origin by the California Energy Resources Conservation and Development Commission (1975), as shown in Table A1.8. However, 16% of the foreign imports were not identified by country.

TABLE A1.8

1973 Foreign Crude Oil Imports to California

	Imports (thousands of barrels)
Saudi Arabia	63,888 (per year)
Qatar	1,635
United Arab Emirates	5,593
Oman	4,053
Syria Arab Republic	300
Kuwait	1,001
Iran	9,533
Indonesia	49,716
Venezuela	6,554
Ecuador	12,935
Australia	203
India	266
Japan	*
Trinidad and Tobago	284
Unidentified	29,397
TOTAL	185,358

*Very small.

This oil was assumed to come uniformly from all of the non-Communist, oil producing nations not listed specifically as exporting to California.

All foreign crude oil was assumed to be imported by ship. Based on available waterborne commerce data (Corps of Engineers, 1973), it was estimated that 110,315 thousand barrels of foreign crude oil entered South Coast Air Basin ports in 1973. That amounts to 59.5% of total California receipts of foreign crude oil. Therefore 59.5% of each of the foreign oils brought to California was assigned to the South Coast Air Basin crude oil pool. The results are shown in Table A1.9. While results are tabulated only for ten major geographic producing regions, the imports to California were computed on a country-by-country basis whenever possible. For that reason, the estimated sulfur content of foreign oils *received in California* from some of the major producing regions is somewhat different than the sulfur content estimated for all crude oil production *originating* in that region as a whole. This simply reflects a greater participation in California trade by some nations in a producing region than was characteristic of the average of all producers in that region.

A1.5 Summary and Discussion

Table A1.10 and Figure A1.1 summarize the estimated crude oil and associated sulfur receipts by South Coast Air Basin customers in 1973. The result is that just over one million barrels of crude oil were received daily containing 3,821 thousand pounds of sulfur per day. These crude oil receipts almost exactly match 1973 South Coast Air Basin refinery capacity of 1,006,200 bbls per stream day (Cantrell, 1973). Data on total 1973 crude oil sulfur intake by Los Angeles

TABLE A1.9

Foreign Crude Oil Received in the South Coast Air Basin - 1973**

Group and Sulfur Content Range	Estimated Average API°	Total Production (1973) (1000's barrels)	% of Total Production (1973)	Average Percent Sulfur by Weight	Imports to California (1000's barrels)	% Sulfur	Estimated Quantity Received in SCAB (1000's barrels)	Approximate Quantity of Sulfur Contained (1000's lbs/year)	Estimated Average Density (lbs per barrel)
Group 1									
Persian Gulf	33.3								300.32
0.00 to 0.25%S		0.0	0.0	---	0.0	---	0.0	0.0	
0.26 to 0.50		0.0	0.0	---	0.0	---	0.0	0.0	
0.51 to 1.00		721,038.9	9.1	0.62	5,929.7	0.62	3,528.9	6,570.8	
1.01 to 2.00		5,880,327.9	74.6	1.63	64,891.3	1.67	38,618.4	193,684.6	
2.01 to 3.00		1,251,327.4	15.9	2.65	19,854.5	2.75	11,815.9	97,585.2	
3.01 to 4.00		30,628.8	0.4	3.68	120.4	3.68	71.7	792.4	
4.01 and up		0.0	0.0	---	0.0	---	0.0	0.0	
Group 1 subtotal		7,883,323.0		1.71	90,795.9	1.83	54,034.9	298,633.0	
Group 2									
(Israel, Turkey, Syria, Egypt)	29.0								308.37
0.00 to 0.25%S		0.0	0.0	---	0.0	---	0.0	0.0	
0.26 to 0.50		0.0	0.0	---	0.0	---	0.0	0.0	
0.51 to 1.00		8,711.4	5.6	0.84	60.7	0.84	36.1	93.5	
1.01 to 2.00		146,407.6	94.4	1.69	1,021.7	1.68	608.0	3,149.8	
2.01 to 3.00		0.0	0.0	---	0.0	---	0.0	0.0	
3.01 to 4.00		0.0	0.0	---	0.0	---	0.0	0.0	
4.01 and up		0.0	0.0	---	0.0	---	0.0	0.0	
Group 2 subtotal		155,119.0		1.64	1,082.4	1.64	644.1	3,243.3	
Group 3									
Africa (North and West Coasts)	37.0								293.73
0.00 to 0.25%S		1,750,943.2	83.3	0.16	11,714.1	0.16	6,971.3	3,276.3	
0.26 to 0.50		160,720.5	7.7	0.31	1,075.3	0.31	639.9	582.7	
0.51 to 1.00		188,053.8	9.0	0.55	1,258.1	0.55	748.7	1,209.5	
1.01 to 2.00		1,046.5	0.0	1.31	7.0	1.31	4.2	16.2	
2.01 to 3.00		0.0	0.0	---	0.0	---	0.0	0.0	
3.01 to 4.00		0.0	0.0	---	0.0	---	0.0	0.0	
4.01 and up		0.0	0.0	---	0.0	---	0.0	0.0	
Group 3 subtotal		2,100,763.8		0.21	14,054.1	0.21	8,364.1	5,084.7	
Group 4									
South Pacific	35.0								297.26
0.00 to 0.25%S		812,270.4	100.0	0.14	51,009.5	0.14	30,357.0	12,633.5	
0.26 to 0.50		0.0	0.0	---	0.0	---	0.0	0.0	
0.51 to 1.00		0.0	0.0	---	0.0	---	0.0	0.0	
1.01 to 2.00		0.0	0.0	---	0.0	---	0.0	0.0	
2.01 to 3.00		0.0	0.0	---	0.0	---	0.0	0.0	
3.01 to 4.00		0.0	0.0	---	0.0	---	0.0	0.0	
4.01 and up		0.0	0.0	---	0.0	---	0.0	0.0	
Group 4 subtotal		812,270.4		0.14	51,009.5	0.14	30,357.0	12,633.5	
Group 5									
S.A., Carib. Coast	27.6								311.08
0.00 to 0.25%S		17,749.6	1.0	0.10	99.8	0.10	59.4	18.5	
0.26 to 0.50		15,307.1	1.3	0.45	79.9	0.46	47.6	68.1	
0.51 to 1.00		144,244.4	10.2	0.80	830.4	0.81	494.2	1,245.3	
1.01 to 2.00		410,412.6	28.9	1.50	2,227.7	1.49	1,325.8	6,145.2	
2.01 to 3.00		800,129.9	56.4	2.40	4,294.2	2.41	2,555.6	19,159.4	
3.01 to 4.00		0.0	0.0	---	0.0	---	0.0	0.0	
4.01 and up		30,388.1	2.1	5.54	163.7	5.54	97.4	1,678.6	
Group 5 subtotal		1,418,231.7		2.00	7,695.7	1.99	4,580.0	28,315.1	
Group 6									
West. S. A.	33.0								300.87
0.00 to 0.25%S		17,485.0	6.2	0.12	36.9	0.12	22.0	7.9	
0.26 to 0.50		0.0	0.0	---	0.0	---	0.0	0.0	
0.51 to 1.00		266,737.1	93.8	1.00+	14,289.8	1.00+	8,504.2	25,586.6	
1.01 to 2.00		0.0	0.0	---	0.0	---	0.0	0.0	
2.01 to 3.00		0.0	0.0	---	0.0	---	0.0	0.0	
3.01 to 4.00		0.0	0.0	---	0.0	---	0.0	0.0	
4.01 and up		0.0	0.0	---	0.0	---	0.0	0.0	
Group 6 subtotal		284,222.1		0.95	14,326.7	1.00	8,526.2	25,594.5	
Group 7									
Europe	33.0								300.87
0.00 to 0.25%S		0.0	0.0	---	0.0	---	0.0	0.0	
0.26 to 0.50		0.0	0.0	---	0.0	---	0.0	0.0	
0.51 to 1.00		0.0	0.0	---	0.0	---	0.0	0.0	
1.01 to 2.00		114,182.7	100.0	1.38*	763.9	1.38*	454.6	1,887.6	
2.01 to 3.00		0.0	0.0	---	0.0	---	0.0	0.0	
3.01 to 4.00		0.0	0.0	---	0.0	---	0.0	0.0	
4.01 and up		0.0	0.0	---	0.0	---	0.0	0.0	
Group 7 subtotal		114,182.7		1.38*	763.9	1.38*	454.6	1,887.6	

+ Ecuadorian crude oil sulfur content assumed to be approximately same as Columbian crude oil.

* Sulfur data subject to great doubt.

** Based on receipt of a representative cross section of California's foreign crude oil imports at South Coast Air Basin ports in 1973.

TABLE A1.9
(continued)

Group and Sulfur Content Range	Estimated Average API°	Total Production (1973) (1000's barrels)	% of Total Production (1973)	Average Percent Sulfur by Weight	Imports to California (1000's barrels)	% Sulfur	Estimated Quantity Received in SCAB (1000's barrels)	Approximate Quantity of Sulfur Contained (1000's lbs/year)	Estimated Average Density (lbs/barrel)
Group 8									
Mexico	27.0								312.26
0.00 to 0.25%S		8,690.5	4.5	0.10	58.1	0.10	34.6	10.8	
0.26 to 0.50		0.0	0.0	---	0.0	---	0.0	0.0	
0.51 to 1.00		0.0	0.0	---	0.0	---	0.0	0.0	
1.01 to 2.00		109,190.1	57.0	1.77	730.5	1.77	434.7	2,402.6	
2.01 to 3.00		4,576.3	2.4	2.57	30.6	2.57	18.2	146.1	
3.01 to 4.00		48,049.4	25.1	3.66	321.4	3.66	191.3	2,186.3	
4.01 and up		20,975.3	11.0	5.19	140.3	5.19	83.5	1,353.2	
Group 8 subtotal		191,481.6		2.56	1,280.9	2.56	762.3	6,099.0	
Group 9									
Canada	36.0								295.48
0.00 to 0.25%S		371,306.2	57.3	0.21	2,484.0	0.21	1,478.3	917.3	
0.26 to 0.50		36,903.8	5.7	0.33	246.9	0.33	146.9	143.2	
0.51 to 1.00		162,925.1	25.1	0.69	1,090.0	0.69	648.7	1,322.6	
1.01 to 2.00		39,009.7	6.0	1.22	261.0	1.22	155.3	559.8	
2.01 to 3.00		38,201.8	5.9	2.12	255.6	2.12	152.1	952.8	
3.01 to 4.00		0.0	0.0	---	0.0	---	0.0	0.0	
4.01 and up		0.0	0.0	---	0.0	---	0.0	0.0	
Group 9 subtotal		648,346.6		0.51	4,337.4	0.51	2,581.3	3,895.7	
Group 10									
Japan & Taiwan	35.0								297.20***
0.00 to 0.25%S		5,717.5	92.3	0.10	38.2	0.10	22.7	6.7	
0.26 to 0.50		0.0	0.0	---	0.0	---	0.0	0.0	
0.51 to 1.00		479.5	7.7	0.52	3.2	0.52	1.9	2.9	
1.01 to 2.00		0.0	0.0	---	0.0	---	0.0	0.0	
2.01 to 3.00		0.0	0.0	---	0.0	---	0.0	0.0	
3.01 to 4.00		0.0	0.0	---	0.0	---	0.0	0.0	
4.01 and up		0.0	0.0	---	0.0	---	0.0	0.0	
Group 10 subtotal		6,197.0		0.13	41.4	0.13	24.6	9.6	

***Estimated from South Pacific Group (#4).

TABLE A1.10

Summary of 1973 South Coast Air Basin
Crude Oil Receipts plus Associated Sulfur Content

Origin of Crude Oil	Average % Sulfur by Weight	1973 Estimated Quantity Received in SCAB (1000's barrels/yr)	1973 Approximate Quantity of Sulfur Contained (1000's lbs/year)
Los Angeles Basin	1.49	128,207.9*	613,878.5
Ventura and Federal Offshore	1.36	41,172.8*	176,503.9
Central California Coast	3.35	8,648.9	99,808.8
San Joaquin Valley	0.81	39,055.4	102,912.4
California subtotal	1.42	217,085.0	993,103.6
Alaska	0.08	26,950.5	6,509.3
Utah	0.27	12,000.1	9,553.5
Domestic Import subtotal	0.14	38,950.6	16,062.8
Group 1 (Persian Gulf)	1.83	54,034.9	298,633.0
Group 2 (Remainder of Middle East)	1.64	644.1	3,243.3
Group 3 (Africa, north and west coast)	0.21	8,364.1	5,084.7
Group 4 (South Pacific)	0.14	30,357.0	12,633.5
Group 5 (South America, Caribbean Coast)	1.99	4,580.0	28.315.1
Group 6 (Western South America)	1.00	8,526.2	25,594.5
Group 7 (Europe)	1.38	454.6	1,887.6
Group 8 (Mexico)	2.56	762.3	6,099.0
Group 9 (Canada)	0.51	2,581.3	3,895.7
Group 10 (Japan & Taiwan)	0.13	24.6	9.6
Foreign Import subtotal	1.16	110,329.1	385,396.0
TOTAL	1.20	366,364.7	1,394,562.4
			(= 3,821 thousand pounds per day)

*Local production less estimated net exports from the basin.

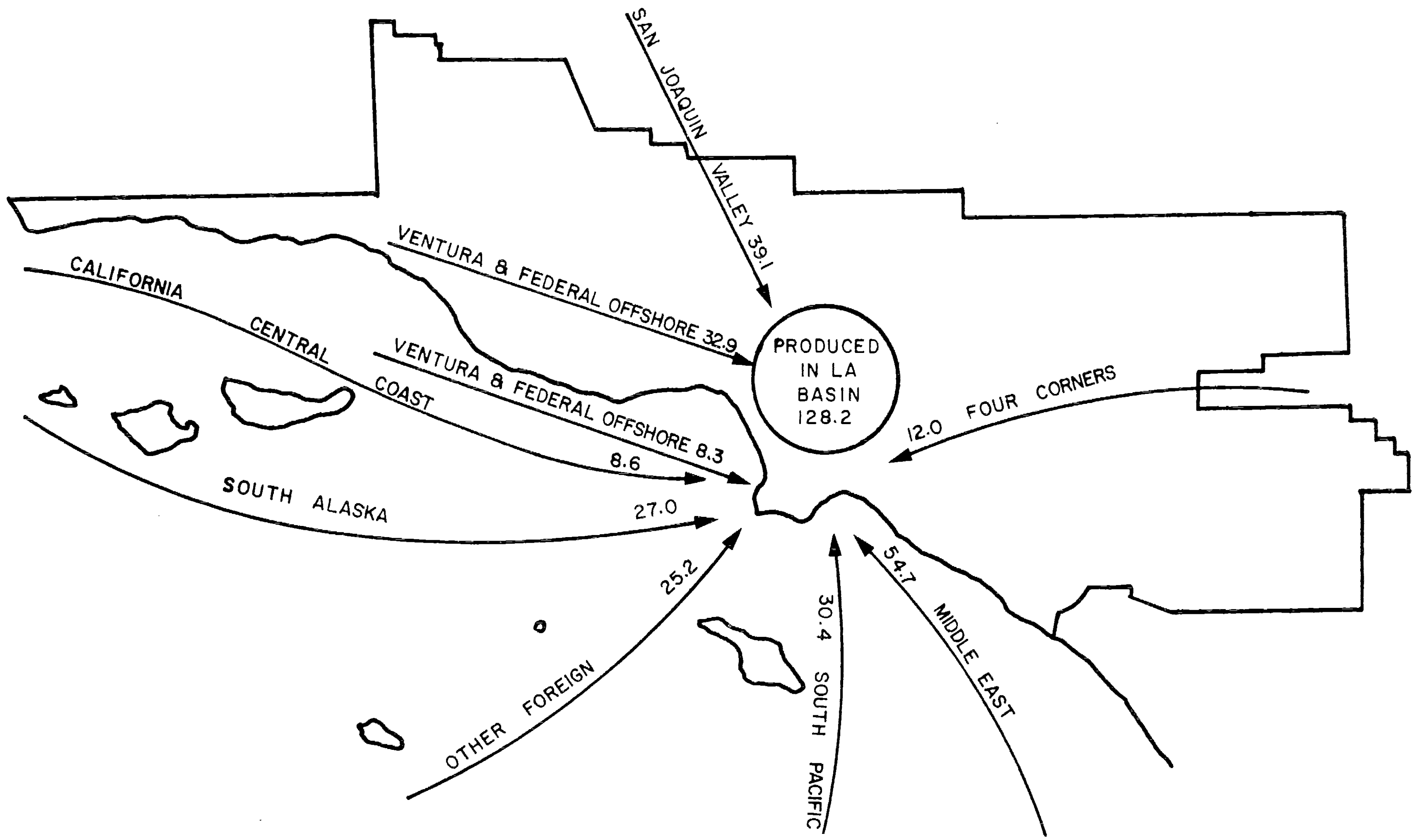


FIGURE A1.1

The Estimated Origin and Quantity of Crude Oils Received by South Coast Air Basin Customers in 1973
(Millions of Barrels per Year)

County refineries has been obtained by the Southern California Air Pollution Control District SCAPD, 1976a). Their data report that 3,551.49 thousand pounds of sulfur arrived daily at Los Angeles County refineries in feedstocks (net of unfinished oils rerun) in that year. This agrees with our independent estimate to within about 7%. There are two very small refineries excluded from the APCD survey which, if included, would probably bring these two sulfur supply estimates into even closer agreement.

In spite of the high gasoline consumption in the Los Angeles area, the South Coast Air Basin uses only a very small portion of total world oil production. This fact is easily seen in Table A1.11. Most importantly, the basin uses but a small part of the very low sulfur (less than 0.25% S) crude oil produced in the world. As seen in the trade maps of Figures A1.2 through A1.4, Japan is the major foreign customer for South Pacific region oil (generally low sulfur), buying more than ten times the amount delivered to the South Coast Air Basin from that producing region. An even smaller fraction of low sulfur African oils are imported to California. It is thus not physically impossible that sulfur input to the South Coast Air Basin could be sharply reduced by substitution of low sulfur crude oils for current high sulfur oil receipts.

However, the practical problems posed by such a fuel switching strategy look very formidable indeed. Figures A1.5 and A1.6 yield several important insights into the nature of the sulfur management problems facing Los Angeles area refineries. In the lowest sulfur

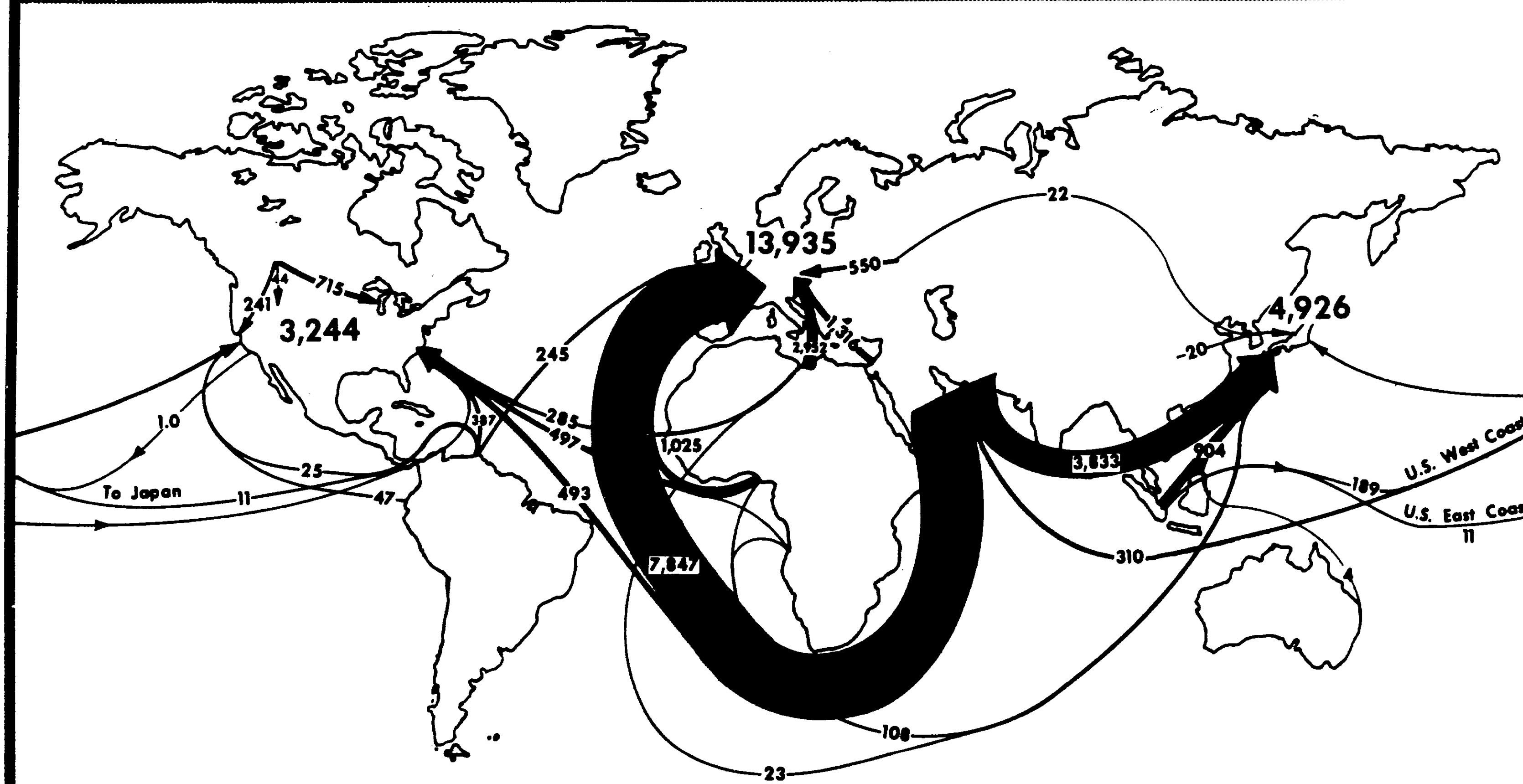
TABLE A1.11

Estimated South Coast Air Basin Crude Oil Receipts
As a Fraction of Oil Available at the Wellhead
in Various Producing Regions

Origin of Crude Oil	Average Percent Sulfur by Weight	1973 Estimated Quantity Consumed in SCAB (1000's barrels/yr)	Percent of total 1973 Production
Los Angeles Basin	1.49	128,207.9	97.0%
Ventura and Federal Offshore	1.36	41,172.8	87.4
Central California Coast	3.35	8,648.9	29.2
San Joaquin Valley	0.81	39,055.4	30.8
California subtotal	1.42	217,085.0	64.7%
Alaska (southern)	0.08	26,950.5	36.9
Utah	0.27	12,000.1	46.2
Domestic Import subtotal	0.14	38,950.6	
Group 1 (Persian Gulf)	1.83	54,034.9	0.7
Group 2 (Remainder of Middle East)	1.64	644.1	0.4[a]
Group 3 (Africa, north and west coasts)	0.21	8,364.1	0.4[a]
Group 4 (South Pacific)	0.14	30,357.0	3.7
Group 5 (South America, Caribbean Coast)	1.99	4,580.0	0.3
Group 6 (Western South America)	1.00	8,526.2	3.0
Group 7 (Europe)	1.38	454.6	0.4[a]
Group 8 (Mexico)	2.56	762.3	0.4[a]
Group 9 (Canada)	0.51	2,581.3	0.4[a]
Group 10 (Japan & Taiwan)	0.13	24.6	0.4[a]
Foreign Import subtotal	1.16	110,329.1	
TOTAL	1.20	366,364.7	

Note: (a) Crude oil coming to the South Coast Air Basin from undesignated countries of origin was distributed amongst all producing regions whose exports to California were not known explicitly.

WORLD CRUDE OIL MOVEMENTS TO MAJOR CONSUMING AREAS - 1973 (thousand barrels per day)



Source: Bureau of Mines (1975a)

FIGURE A1.2

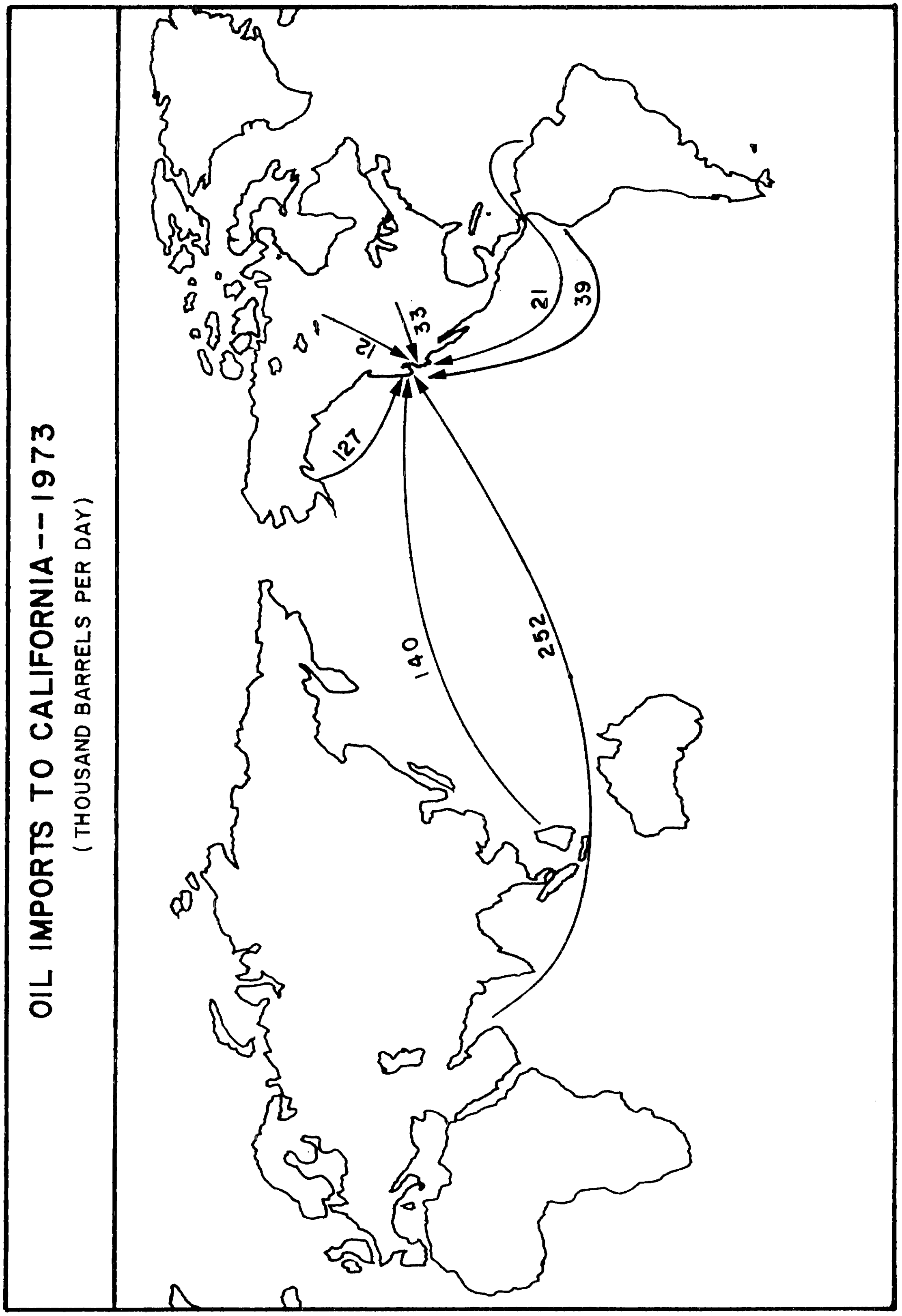

OIL IMPORTS TO CALIFORNIA -- 1973
(THOUSAND BARRELS PER DAY)
12
33
21
39
127
140
252
39

FIGURE A1.3

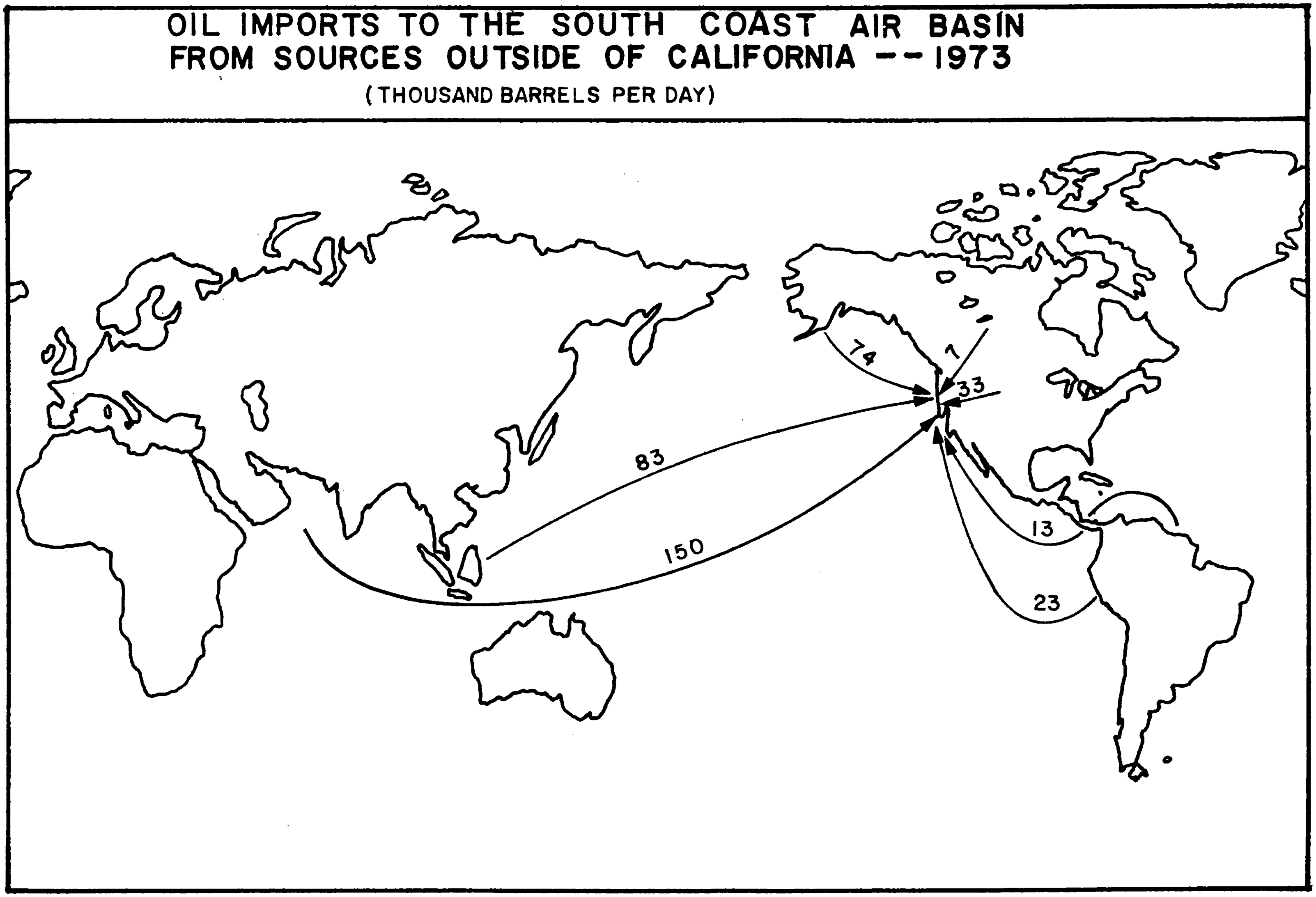

OIL IMPORTS TO THE SOUTH COAST AIR BASIN
FROM SOURCES OUTSIDE OF CALIFORNIA -- 1973
(THOUSAND BARRELS PER DAY)
74
7
33
83
150
13
23

FIGURE A1.4

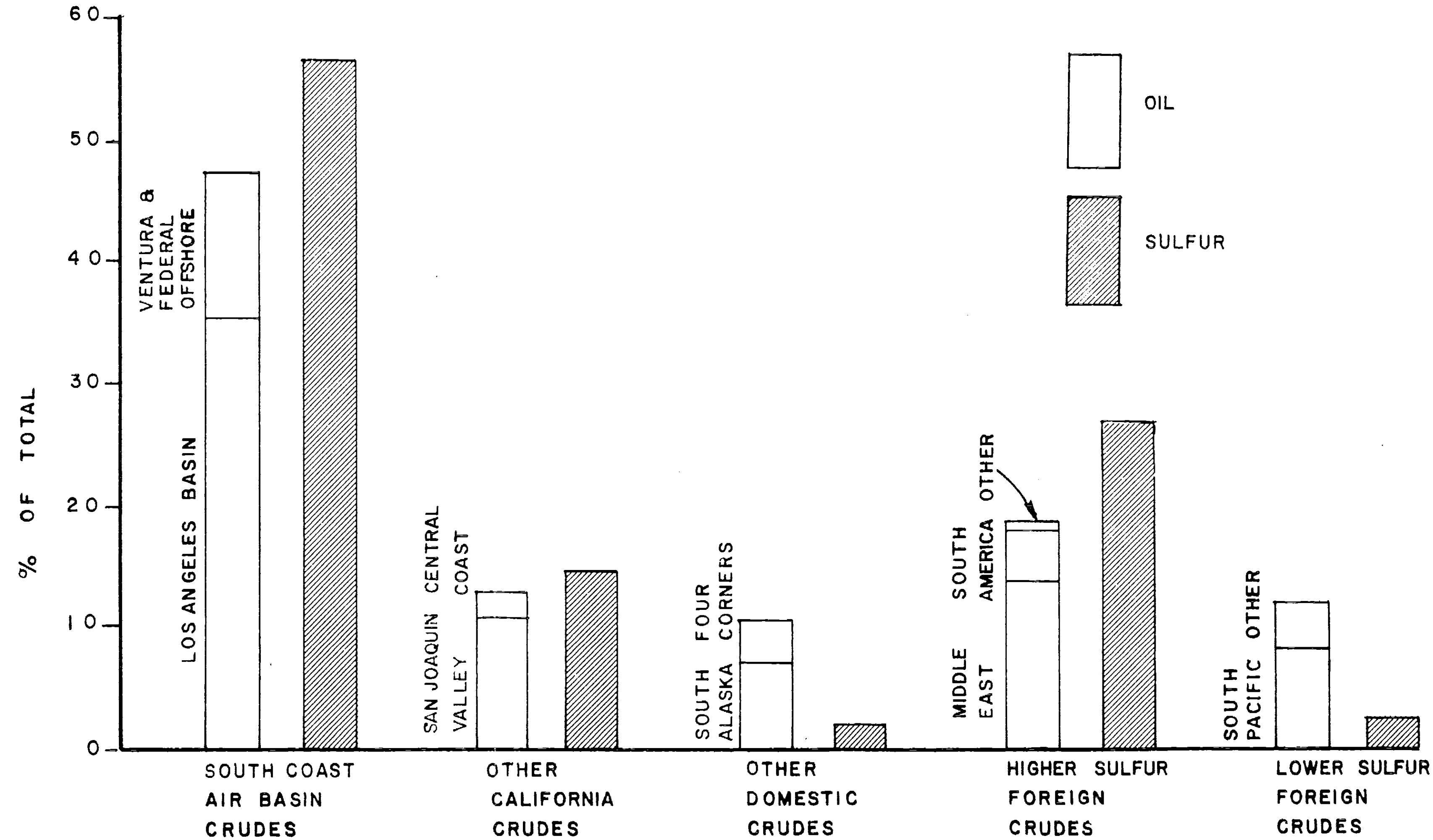


FIGURE A1.5

Fraction of Crude Oil and Sulfur coming to the South Coast Air Basin from Various Oil Producing Regions of the World-1973

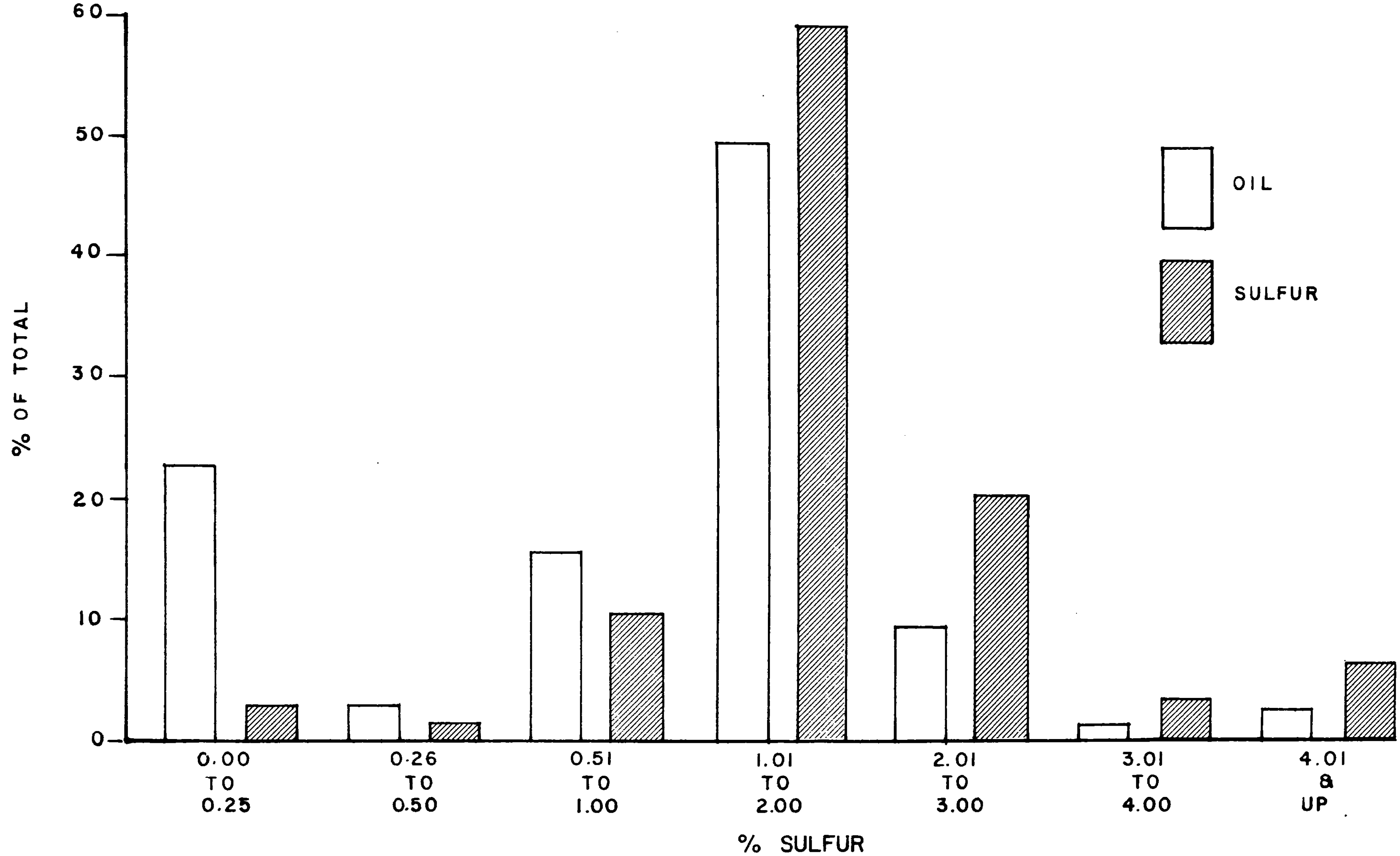


FIGURE A1.6

The Distribution of Crude Oils by Sulfur Content Received in the South Coast Air Basin in 1973 category (<0.25% S) 22% of the total oil contributes only 2% to the total sulfur burden on basin oil refineries, while in the 2.01% and higher sulfur categories, 12% of the total oil contributes 28.5% of the sulfur. Even so, the major portion of sulfur supply to the air basin comes from the 1.01 to 2.00% sulfur category where 49% of the total oil contributes 59% of the total sulfur. That 1.01% to 2.00% sulfur category is dominated by local crude oils produced in the Los Angeles and Ventura oil fields. One cannot easily divert this source of supply to other ports because the supply is already landed ashore. Substantial alteration of transfer and storage facilities would be needed if that oil were to be sold elsewhere. Thus, locally produced crude oil would be difficult to displace by importation of alternate low-sulfur crude oils. The South Coast Air Basin is apparently saddled with a sulfur management problem that is not likely to be exported elsewhere as long as local crude oils are processed in local refineries.

References for Appendix A1

Bureau of Mines (1976), Fuel Oil by Sulfur Content, Monthly, U. S. Department of the Interior, Mineral Industry Surveys, December 1976 issue.

Bureau of Mines (1975a), Minerals Yearbook, Volume I, Metals, Minerals and Fuels, 1973, Washington D.C., U. S. Government Printing Office, U. S. Department of the Interior.

Bureau of Mines (1975b), Sulfur Content of Crude Oils, by M. Carrales Jr. and R. W. Martin, Washington, D. C., U. S. Government Printing Office, U. S. Department of the Interior, Bureau of Mines Information circular 8676.

California Division of Oil and Gas (1973), 59th Annual Report of the State Oil and Gas Supervisor, Oil Gas and Geothermal Production Statistics 1973, Sacramento, California, State of California, the Resources Agency of California.

California Division of Oil and Gas (1974), 60th Annual Report of the State Oil and Gas Supervisor, Sacramento, California, State of California.

California Energy Resources Conservation and Development Commission (1975), Energy Shortage Contingency Plan, Sacramento, California, State of California.

Cantrell, A. (1973), "Annual Refining Survey", The Oil and Gas Journal, Vol 71, No. 14, April 2, 1973.

Corps of Engineers (1973), Waterborne Commerce of the United States, Calendar year 1973, Part 4, Waterways and Harbors Pacific Coast, Alaska and Hawaii, U. S. Department of the Army.

Joint Committee on the Public Domain (1974a), Cost of Refining California Crude Oil, a report of the California State Legislature, October 1974.

Joint Committee on the Public Domain (1974b), Crude Oil Pipelines in California, a report of the California State Legislature, October 1974.

McCaslin, J. C., editor (1974) International Petroleum Encyclopedia, Tulsa, Oklahoma, The Petroleum Publishing Company.

Nehring, R. (1975), Oil and Gas Supplies for California: Past and Future, Santa Monica, California, The Rand Corporation, document R-1850-CSA/RF.

Southern California Air Pollution Control District (1976a), personal communication. The District furnished an abbreviated version of their internal document entitled "Sulfur Balance - Los Angeles County Refineries - 1973".

APPENDIX A2
EMISSIONS ESTIMATES FOR INDIVIDUAL SOURCES

A2.1 Methodology

This appendix describes the assembly of an inventory of sulfur oxides emissions in the central portion of the South Coast Air Basin. Estimates were made of the emissions from over two thousand five hundred stationary sources and from seven classes of mobile sources for each month of the years 1972 through 1974. A general description of the approach used in assembling this inventory will be given first, followed by a detailed description of the emission estimation procedure for each source type.

In Figure A2.1, a square area 50 miles on each edge is shown superimposed over the central portion of the South Coast Air Basin. That square has been subdivided into a system of grid cells with a two mile spacing between adjacent cell boundaries. This grid system is suitable for use in displaying sulfate air quality model results since it substantially covers those areas of the air basin for which extensive air quality data are available for model validation. For historic reasons, the grid system is also convenient for compiling and displaying a detailed sulfur oxides source emission inventory. Each two mile by two mile grid cell corresponds to a combination of four one square mile areas used by the Southern California APCD to identify point source locations. Secondly, this grid system closely matches that used by Roth, et al. (1974) to display baseline traffic counts for Los Angeles for the year 1969 which are widely used by other air quality modeling groups. An attempt will be made here to

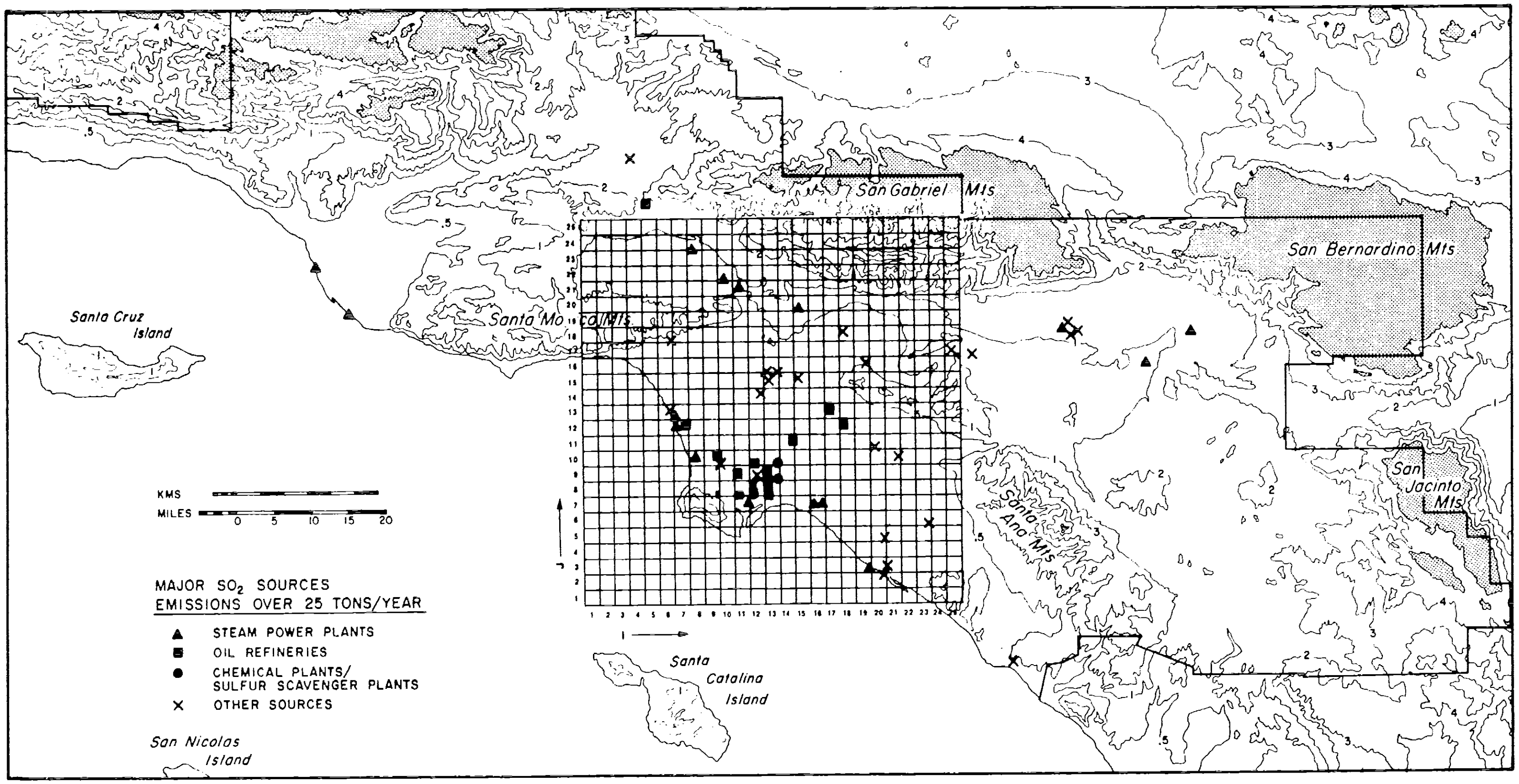


FIGURE A2.1

The Central Portion of the South Coast Air Basin Showing the Grid System Used

develop inventory information which may assist the on-going efforts of other investigators. The grid system employed does not cover the outlying areas of the airshed. An air quality model constructed to use this inventory should thus be capable of handling the few major off-grid sources that will be detailed later in this report.

Los Angeles Air Pollution Control District (1975) historical emission summaries were consulted to obtain an idea of the relative magnitude of various classes of emission sources. The inventory was subdivided into mobile and stationary source categories, and the stationary sources were approached first. Los Angeles APCD permit files were consulted, and an APCD computerized data listing entitled "Emissions by ID Number" was selected for initial study. From this data base (hereafter referred to as the permit file) the location, ownership, equipment type and permit file emissions estimates were obtained for 2003 stationary source equipment items in Los Angeles County. Data on all equipment items listed as current sulfur oxides emitters were copied, as well as data on all boilers and all miscellaneous NO_x emission sources at premises with NO_x emissions of greater than 50 pounds per week. Boilers and other NO_x emission sources were considered as *potential* SO_x emission sources in the event that their natural gas supply was curtailed.

While emissions data were thus acquired for a large number of sources, it was quickly determined by conversation with APCD staff members that much of this permit file emission data was out-dated or reflected source operation on only one type of fuel while fuel switching from oil to gas was known to be practiced on a seasonal basis. The permit file emissions inventory is thus best suited to serve as an equipment list around which better emissions estimates might be organized.

The equipment list was therefore subdivided into fuel burning equipment, industrial process equipment, and incinerators. The permit file emissions data for fuel burning sources were discarded, and month by month emissions from fuel burning sources were estimated from actual fuel use data available for electric utilities, oil refineries, major industries and small natural gas users, as will be described in detail later in this appendix. In the course of this investigation, several hundred additional fuel burning sources were located and added to the inventory.

Next, items of industrial process equipment emitting over one hundred pounds of SO_x per week were isolated, and APCD staff engineers responsible for overseeing those sources were interviewed. As a result of this interview procedure, additional emission sources were located that were not yet a part of the computerized permit files, and better estimates were made of emissions from chemical plants, oil refineries, coke calcining kilns, glass furnaces and secondary lead smelters.

With the core of the stationary source emission data established, survey efforts were expanded beyond Los Angeles County. The source survey and staff interview procedures were repeated at the offices of the Southern California APCD-Southern Zone (formerly the Orange County APCD). Fuel burning data on power plants located outside of Los Angeles County were acquired from the Southern California Edison

Company. Major off-grid sources in San Bernardino and Riverside Counties were reviewed with the help of Southern California APCD staff. The operators of some emissions sources were contacted in order to firm-up data needed to make emission estimates.

Shortly after these emissions data from stationary sources were compiled, a detailed stationary source SO_x emission inventory prepared independently by Hunter and Helgeson (1976) became available for 1974, one of our three years of interest. The two inventories were cross-checked for the year in which they overlap, with generally excellent agreement. Additions and corrections were made to our inventory to reflect certain cases in which Hunter and Helgeson's source test data were thought to present a more recent picture of source operation than was otherwise available. In most cases, however, the time sequence of emissions estimated from our fuel burning records and discussion with APCD staff were retained since they represented a longer historic period of observation, and were usually quite close to Hunter and Helgeson's estimates for the year in which both inventories overlap. Hunter and Helgeson's data for the fraction of each source's emissions evolved as SO_3 were adopted to supplement the APCD data base.

Finally, mobile source emissions categories for autos and light trucks, heavy duty vehicles, ships, railroads and aircraft were established. Freeway traffic counts were performed for each year of the three year period 1972 through 1974. A surface street traffic growth survey was used to update existing 1969 surface street traffic data to the years of interest. Then the traffic count data were used to estimate motor vehicle SO_x emissions for freeways and for surface streets on a spatially resolved basis. Shipping activities and railroad track mileage were assigned geographically to the grid system. Then fuel use by ships and railroads was scaled down to the grid system from the basin-wide fuel use data developed in the Energy and Sulfur Balance portion of this report (see Appendix A3). Aircraft emissions were estimated on the basis of the number of take-off and landing operations at each airport and military air base within our grid system.

A2.2 Stationary Source Fuel Combustion Estimates for Individual Sources

Stationary source fuel combustion is the largest single activity contributing to sulfur oxides emissions in the South Coast Air Basin. While most sulfur oxides emissions arise from combustion of fuel oil, it is more convenient to classify combustion sources by their priority for receiving natural gas. This is because natural gas has been the traditional fuel of first choice within the Los Angeles basin. Fuel oil usually is burned only when gaseous fuels have been curtailed to a given class of user. By keying on the availability of gaseous fuels, one can make estimates of oil combustion by curtailed natural gas customers, even if only their priority for receiving gas is known explicitly. The source classes used to represent stationary source fuel combustion are:

- Electric Utilities
- Petroleum Refineries
- Other Interruptible Gas Customers
- Firm Natural Gas Customers

A2.2.1 Electric Utilities

Eighteen separately inventoried electric generating stations within the South Coast Air Basin are listed in Table A2.1. Thirteen of these plant sites are located within the 50 by 50 mile square grid, while the remainder are off-grid sources whose emissions will still be entered into the air quality model calculations.

Data on total monthly fuel combustion at each utility site within Los Angeles County were copied from the files of the Southern California Air Pollution Control District-Metropolitan Zone (formerly the Los Angeles Air Pollution Control District). These data were available for fuel oil, natural gas and sewage digester gas in units of barrels of equivalent fuel oil use. An APCD equivalent barrel of fuel oil was defined as having an energy content of 6.3×10^6 BTU's (Zwiacher, 1976). The APCD records draw no distinction between residual and distillate fuel oil use at power plants. The sulfur content of fuel oil burned was also recorded for each plant for each month.

All power plants located within the air basin but outside of Los Angeles County are operated by Southern California Edison Company (SCE). Data on their fuel consumption and sulfur content for each month of the years of interest were furnished by the SCE staff (Krumwiede, 1976). In the case of these Edison Company plants, both distillate and residual fuel oil use were reported, along with natural gas consumption.

Since the Southern California APCD data made up the bulk of the

TABLE A2.1

South Coast Air Basin Electric Generating Stations

Grid Square Location East/West I	Grid Square Location North/South J	Identification		County	1973 Generating Capacity[a] (MEGAWATTS) Steam Generators	Gas Turbines
ON-GRID		.13 Electric Generating Stations within the 50 by 50 mile grid				
7	12	SCE[b]	El Segundo Power Plant	Los Angeles	1020	
8	10	SCE	Redondo Power Plant	Los Angeles	1602	
12	7	SCE	Long Beach Power Plant	Los Angeles	212	
16	7	SCE	Alamitos Power Plant	Los Angeles	1950	121
19	3	SCE	Huntington Beach Power Plant	Orange	870	121
7	13	LADWP[c]	Scattergood Power Plant, El Segundo	Los Angeles	360	
8	24	LADWP	Valley Power Plant, Sun Valley	Los Angeles	550	
11	7	LADWP	Harbor Power Plant, Wilmington	Los Angeles	425	80
16	7	LADWP	Haynes Power Plant, Los Alamitos	Los Angeles	1670	
10	22	City of Burbank Power Plants		Los Angeles	175	40
11	21	City of Glendale Power Plant		Los Angeles	150	20
15	20	City of Pasadena - Glenarm		Los Angeles	70	
15	20	City of Pasadena - Broadway		Los Angeles	160	
OFF GRID		5 Electric Generating Stations located beyond the 50 by 50 mile grid				
-15	20	SCE	Ormond Beach	Ventura	1500	
-17	23	SCE	Mandalay	Ventura	430	121
32	19	SCE	Etiwanda	San Bernardino	904	121
38	16	SCE	Highgrove	San Bernardino	154	
41	18	SCE	San Bernardino	San Bernardino	126	

(a) References: SCE data from Southern California Edison (1973); all other data from LAAPCD's "1974 Profile of Air Pollution Control" (Birakos, 1974).
(b) SCE - Southern California Edison Co.
(c) LADWP - Los Angeles Department of Water and Power

emissions information, energy consumption was inventoried at the APCD's stated factor of 6.3×10^6 BTU's per equivalent barrel of fuel oil. Digester gas quantities were adjusted downward from the APCD's assumed energy content of 1060 BTU's per cubic foot to an energy content of 600 BTU's per standard cubic foot based on discussions with the operators of the Hyperion treatment plant (personal communication, Rojas, 1976) which supplies digester gas to the adjacent Scattergood power plant. Energy derived from natural gas was inventoried at 6.3×10^6 BTU's per equivalent barrel for the APCD data, and at 1.06×10^6 BTU's per MCF for the Edison Company data. Distillate fuel oil identified as such by the Edison Company was recorded at the API's standard conversion factor of 5.84×10^6 BTU's per bbl, although the API gravity of this oil was so light that the energy content may be somewhat lower.

Sulfur oxides emissions from electric utility fuel burning were estimated using the following emission factors:

Fuel Type	lbs. SO_x per fuel oil equivalent barrel
Fuel Oil (residual or unidentified)	6.384 times %S
Distillate Fuel Oil	5.737 times %S
Digester Gas	1.1234
Natural Gas	0.00357

The residual fuel oil factor used here corresponds to an API gravity of 24, in the middle of the range of residual fuel oils used at Edison Company plants for which we had the data. Residual fuel oil gravity occasionally dropped as low as API 13.5 or went as high as API 30.9. A narrower range of distillate oil gravity fluctuations was observed. Our emission factor for distillate turbine fuel is based on an API gravity of 41.5, again taken on the middle of the range of the Edison Company's experience.

Fuel oil emission factors must be multiplied by the weight percent sulfur (%S) content of the fuel at each plant for each month. While performing this calculation, the consumption weighted average sulfur content of electric utility residual fuel oil was computed for the entire air basin for each year of interest, as shown in Table A2.2. Residual fuel oil sulfur content averaged about 14 percent below the legal limit of 0.5% sulfur by weight prevailing during the years of interest. Distillate oils used for peaking turbines were substantially below the legal limit on the sulfur content of fuels. During the period of interest, fuel oils with a sulfur content greater than 0.5% by weight were burned on occasion at the Glendale Power Plant and at SCE's Highgrove Generating Station. The Highgrove station is equipped with an experimental stack gas cleaning system which scrubs the effluent gas down to slightly less than the equivalent of burning 0.5% sulfur fuel oil. The effect of this emission control equipment was factored into the emission inventory.

The sulfur content of natural gas is so low that total fuel burning SO_x emissions are insensitive to the exact choice of emission factors. The natural gas emission factor used here represents a typical United States natural gas analysis cited by the U. S. Environmental Protection Agency (1973). The H_2S content of the Hyperion treatment plant's digester gas (Rojas, 1976) is used as the basis for the digester gas emission factor given for power plants.

TABLE A2.2

Consumption Weighted Sulfur Content of Utility Fuels

(As Weight Percent Sulfur)

Year	Residual Fuel Oil (a)
1972	0.420
1973	0.439
1974	0.436

(a) Calculated from monthly fuel use and sulfur content of fuel at all South Coast Air Basin power plants.

Table A2.3 shows the emissions and energy consumption history for three years of fuel burning behavior at all eighteen generating plants in the South Coast Air Basin. Total energy consumption is relatively constant throughout the seasons of the year, while sulfur oxides emissions peaked strongly during the winter months. This is due to substitution of fuel oil for natural gas during those months when higher priority home heating demands diverted gas from the power plants.

In Figures A2.2 and A2.3, those electric utility sulfur oxides emissions which fall within the 50 by 50 mile square grid are shown by geographic location for a typical summer and a typical winter month. The largest power plants are located adjacent to the coastline in an arc stretching from El Segundo on the north to Huntington Beach on the south. Sulfur oxides emissions from these on-grid power plants are compared to total emissions within the 50 by 50 mile square grid in Figure A2.4. During the winter months, power plants contributed about half of the man-made sulfur oxides emissions to the atmosphere. Summertime behavior varied according to the availability of natural gas and imported out-of-basin electricity. In the summer of 1972, power plant emissions were negligible, while in the summer of 1973 power plants often contributed about half of the on-grid SO_x emissions from stationary sources.

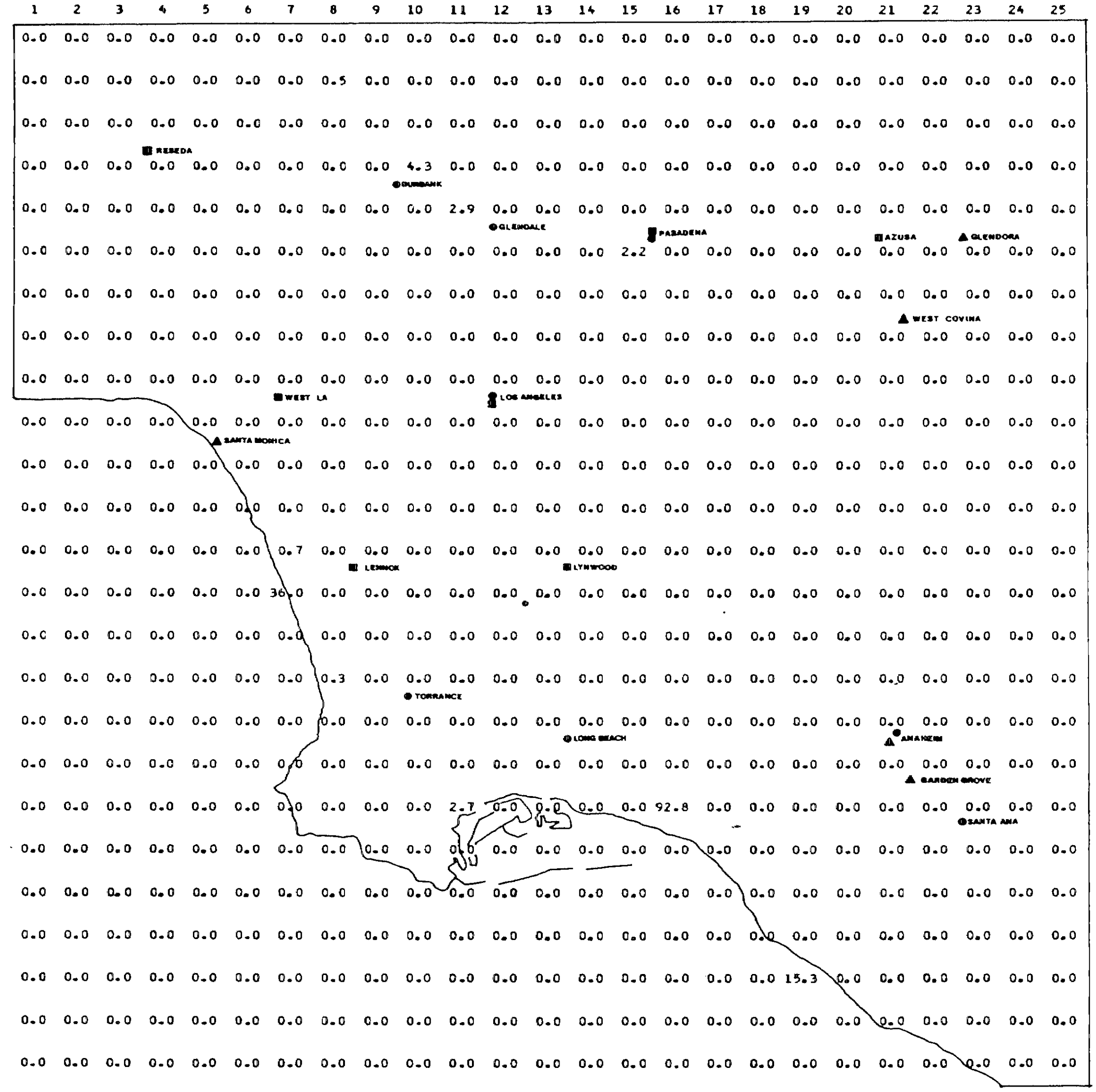
Both plume rise and total emission rates are modulated by a diurnal variation in average power plant load. Los Angeles area power plant loads generally peak in the late afternoon, and reach a minimum late at night. Data on the typical diurnal variation in

TABLE A2.3

Electric Utility Fuel Combustion and SO_x Emissions

YEAR	MONTH	Heat Input by Fuel Type (in 10^9 BTUs for each month) at 18 Thermal-Electric Generating Stations in the Entire South Coast Air Basin				SULFUR OXIDES EMISSIONS			
						13 Plants within 50 by 50 mile grid		18 Plants within entire South Coast Air Basin	
		NATURAL GAS	FUEL OILS	SEWAGE DIGESTER GAS	TOTAL HEAT INPUT	TONS	TONS/DAY	TONS	TONS/DAY
1972	JAN	5501.84	40768.24	15.92	46286.00	6660.80	214.86	8388.61	270.60
	FEB	19314.41	20292.99	16.06	39623.44	3580.46	123.46	4285.50	147.78
	MAR	25005.89	14424.92	18.35	39449.16	2590.34	83.56	3110.72	100.35
	APR	30145.43	4312.69	22.31	34480.43	716.89	23.90	919.53	30.65
	MAY	29522.13	6938.69	18.86	36479.67	1188.16	38.33	1497.81	48.32
	JUN	31962.71	4261.95	19.94	36244.60	719.30	23.98	899.83	29.99
	JUL	40964.35	4090.29	17.01	45071.65	574.60	18.54	869.85	28.06
	AUG	41252.14	6238.98	13.59	47504.70	998.77	32.22	1324.82	42.74
	SEP	32907.56	11636.25	14.80	44558.61	1871.93	62.40	2458.71	81.96
	OCT	18732.73	22462.11	16.60	41202.43	3931.26	126.81	4835.91	156.00
	NOV	7236.34	39060.58	15.73	46312.63	6718.92	223.96	8451.91	282.00
	DEC	5667.25	41200.16	5.45	46872.85	6980.39	225.17	8954.28	288.85
	TOTAL	288203.75	215687.81	194.62	504086.13	36531.81	99.81	46005.48	125.70
1973	JAN	3195.38	42660.68	18.53	45874.59	7215.82	232.77	9081.86	292.96
	FEB	7975.84	33543.60	18.67	41538.10	5944.82	212.31	7217.69	257.77
	MAR	7364.64	38710.22	20.01	46094.85	6576.00	212.13	8372.21	270.07
	APR	16327.59	21596.20	16.10	37939.88	3700.73	123.36	4876.11	162.54
	MAY	17070.47	25747.71	16.56	42834.73	4323.85	139.48	5986.04	193.10
	JUN	20869.75	29484.31	14.20	50368.25	4915.98	163.87	6856.49	228.55
	JUL	24268.87	28751.75	12.30	53032.90	4890.88	157.77	6567.14	211.84
	AUG	19731.02	33605.89	9.84	53346.74	5865.99	189.23	7694.29	248.20
	SEP	16012.41	30363.26	8.93	46384.60	5224.94	174.16	6586.20	219.54
	OCT	14906.33	35576.74	8.39	50491.45	5953.45	192.05	7803.86	251.74
	NOV	6712.68	43079.09	9.35	49801.12	6891.69	229.72	9644.05	321.47
	DEC	5277.04	30902.14	7.08	36186.25	4819.74	155.48	6880.05	221.94
	TOTAL	159712.00	394021.59	159.95	553893.44	66323.88	181.71	87565.94	239.91
1974	JAN	4363.85	33761.03	8.37	38133.23	5153.29	166.24	7247.07	233.78
	FEB	4334.70	23867.64	9.32	28211.64	3337.42	119.19	5172.09	184.72
	MAR	9189.31	19796.25	13.89	28999.45	3132.43	101.05	4356.54	140.53
	APR	10907.91	14372.89	10.03	25290.84	2331.93	77.73	3127.21	104.24
	MAY	10038.88	18333.29	11.86	28384.04	3011.93	97.16	4075.73	131.48
	JUN	11949.42	21450.18	11.04	33410.64	3395.66	113.19	4822.48	160.75
	JUL	15138.05	22213.34	0.00	37351.39	3442.02	111.03	4973.08	160.42
	AUG	17086.31	18448.59	6.29	35541.18	2611.24	84.23	4213.39	135.92
	SEP	14965.35	24857.00	4.95	39827.30	3839.27	127.98	5376.05	179.20
	OCT	12419.19	27718.69	3.96	40141.84	4613.60	148.83	6067.89	195.74
	NOV	5269.44	34118.86	7.05	39395.35	5927.96	197.60	7612.54	253.75
	DFC	977.33	39181.87	8.99	40168.18	6668.28	215.11	8794.50	283.69
	TOTAL	116639.69	298119.58	95.75	414855.06	47465.01	130.04	65838.56	180.38

ELECTRIC UTILITY SOX EMISSIONS FOR YEAR 1973 , MONTH 7 IN TONS/DAY AS SO2



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
24	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
19	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12	0.0	0.0	0.0	0.0	0.0	0.0	36.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.7	0.0	0.0	0.0	0.0	92.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.3	0.0	0.0	0.0	0.0	0.0	0.0
2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

SOX TONS/DAY	FRACTION AS SO3
157.770	0.030

(July 1973)

FIGURE A2.2

ELECTRIC UTILITY SOX EMISSIONS FOR YEAR 1973 , MONTH 1 IN TONS/DAY AS SO2

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
24	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
19	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13	0.0	0.0	0.0	0.0	0.0	0.0	7.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12	0.0	0.0	0.0	0.0	0.0	0.0	25.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	31.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.7	0.0	0.0	0.0	0.0	109.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	24.8	0.0	0.0	0.0	0.0	0.0	0.0
2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

RESEDA
BURBANK
GLENDALE
PASADENA
AZUSA
GLENDORA
WEST COVINA
WEST LA
LOS ANGELES
SANTA MONICA
LENNOX
LYNWOOD
TORRANCE
LONG BEACH
ANAHEIM
GARDEN GROVE
SANTA ANA

SOX TONS/DAY 232.768

FRACTION AS SO3 0.030

(January 1973)

FIGURE A2.3

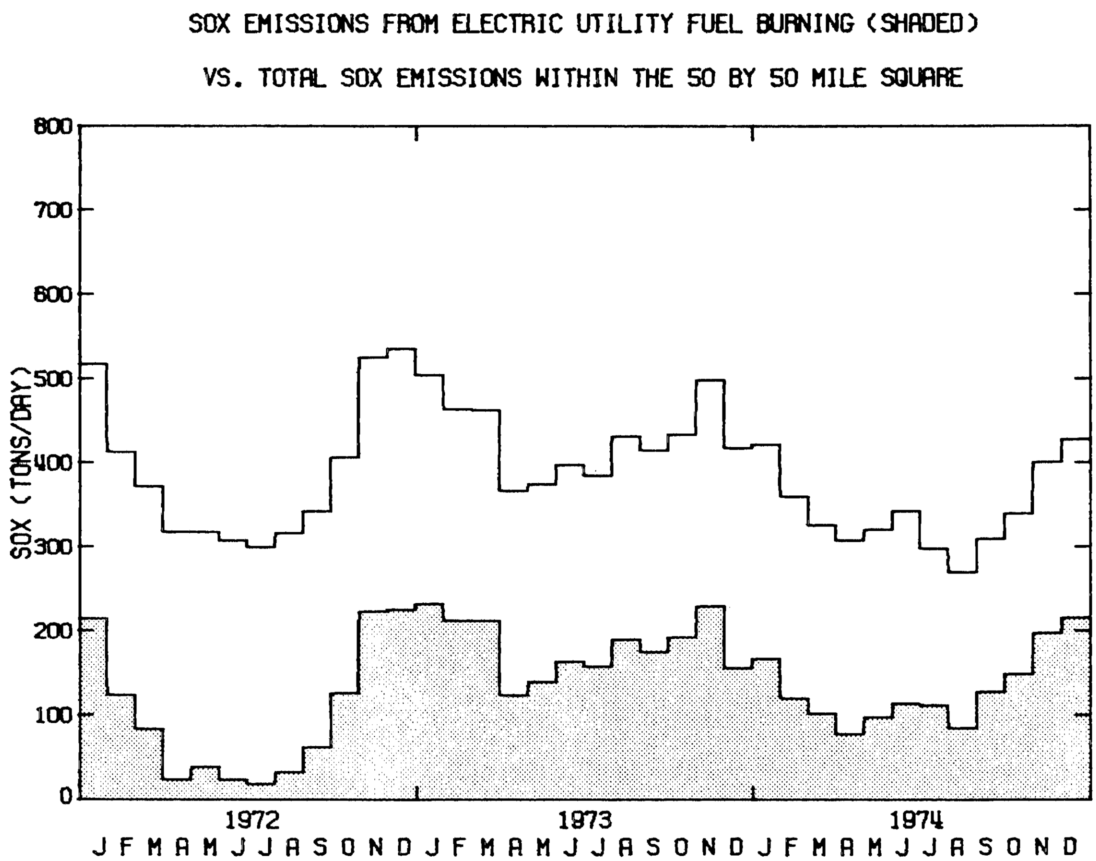

SOX EMISSIONS FROM ELECTRIC UTILITY FUEL BURNING (SHADED)
VS. TOTAL SOX EMISSIONS WITHIN THE 50 BY 50 MILE SQUARE
SOX (TONS/DAY)
0
100
200
300
400
500
600
700
800
1972
1973
1974
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D

FIGURE A2.4

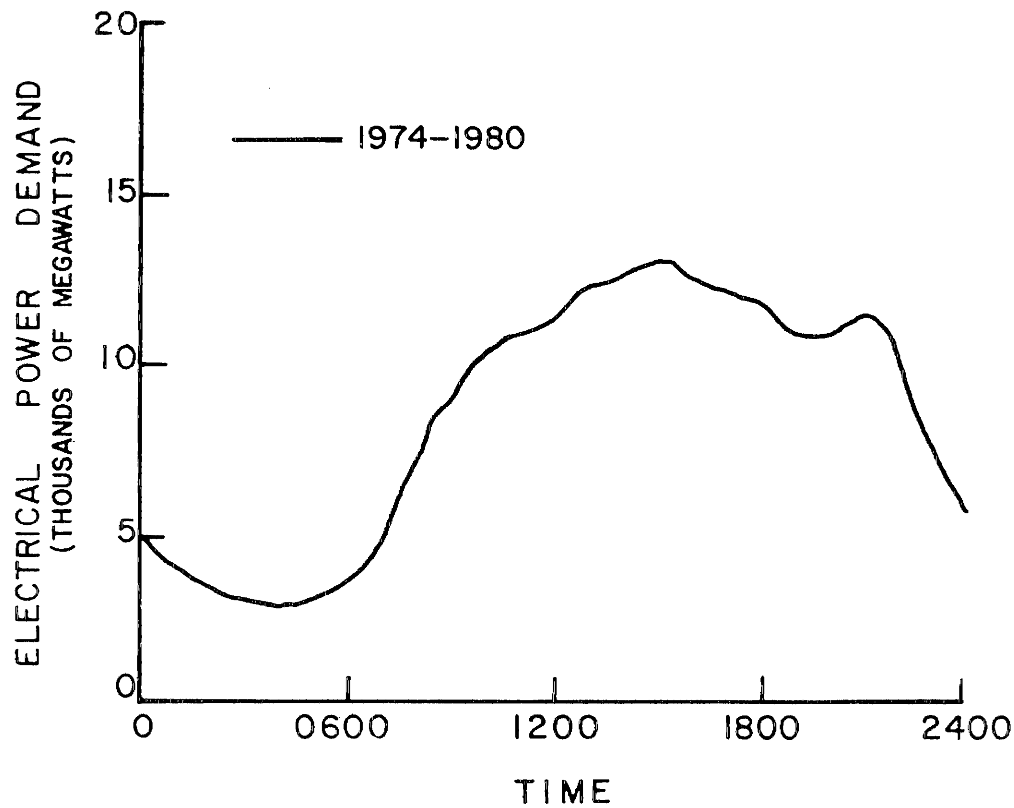
power plant loading in the Los Angeles area is given by Sjovold (1973) as shown in Figure A2.5.

A2.2.2 Refinery Fuel Burning

Petroleum refining is the second largest activity contributing to stationary source fuel combustion SO_x emissions within the South Coast Air Basin. Table A2.4 lists fifteen refinery plant sites within the 50 by 50 mile square grid, all of them located in Los Angeles County. Off-grid refineries are negligible fuel burning emission sources by comparison.

Data on total monthly fuel combustion at each on-grid refinery were copied from the files of the Southern California APCD-Metropolitan Zone. Fuel consumption data were available for fuel oil, refinery gas, natural gas and sewage digester gas in units of equivalent barrels of fuel oil use. Energy use was inventoried by the methods previously detailed for electric utility fuel. Since the sulfur content of refinery gas is not given explicitly in the APCD files, the total monthly SO_x emission in tons per month for each refinery were taken directly from APCD records. Back calculating the sulfur content of refinery gas by subtracting fuel oil combustion SO_x emissions from total SO_x emissions, it appears that refinery gases had an average sulfur content of about 10 grains per hundred cubic feet for the year 1972, and 6 to 7 grains per hundred cubic feet for 1973 and 1974. This is well below the legal limit of 50 grains per hundred cubic feet.

Table A2.5 details the emissions and energy consumption history



Projected Baseline Diurnal Power Demand on Oil Fired Power Plants in the South Coast Air Basin (From Sjovold, 1973).

FIGURE A2.5

TABLE A2.4

15 Petroleum Refineries Within the 50 by 50 Mile Study Area

Grid Square Location East/West I	Grid Square Location North/South J	Identification	Location	1973 Crude Oil (a) Capacity (bbl/stream day)
7	12	Standard Oil of California	El Segundo	220,000
9	10	Mobil Oil	Torrance	130,000
11	8	Union Oil	Wilmington	107,000
11	9	Fletcher Oil & Refining	Carson	16,000
11	10	Carson (Golden Eagle)	Carson	7,000
12	10	Shell Oil (Wilmington)	Wilmington	88,000
12	8	Champlin Petroleum	Wilmington	30,000
12	8	Texaco Inc.	Wilmington	77,000 (b)
12	9	Atlantic Richfield	Carson	173,000
12	10	Shell Oil (Dominguez)	Dominguez	(c)
14	8	MacMillan Ring Free Oil	Signal Hill	10,000
14	11	Edgington Oil	Long Beach	16,000
15	12	Douglas Oil	Paramount	36,000
17	13	Powerline Oil	Santa Fe Springs	30,000
18	12	Gulf Oil	Santa Fe Springs	52,000

(a) Reference: Cantrell (1973)

(b) Barrels per calendar day

(c) Not reported separately, presumed to be included with capacity given for Shell (Wilmington)

(d) Other very small refineries: Lunday - Thagard Oil Co. (5,200 bbl/sd) - included with industrial interruptible gas customers
Newhall Refining (6,500 bbl/sd) and
Edgington Oxnard Refinery (2,500 bbl/sd) - both off-grid.

TABLE A2.5

Fuel Burning and SO_x Emissions: 15 Petroleum Refineries within the 50 by 50 Mile Grid

YEAR	MONTH	HEAT INPUT BY FUEL TYPE (in 10^9 BTUs for each month) NATURAL GAS	FUEL OILS	SEWAGE DIGESTER GAS	REFINERY GAS	TOTAL HEAT INPUT	SO_x EMISSIONS tons	tons/day
1972	JAN	2993.10	2725.59	0.0	9027.01	14745.70	548.40	17.69
	FEB	4941.21	501.62	0.0	8438.34	13881.17	167.50	5.78
	MAR	4398.57	164.67	0.0	8756.25	13319.49	113.40	3.66
	APR	4305.74	126.99	0.0	9026.23	13458.96	286.60	9.55
	MAY	5502.90	57.95	0.0	8721.02	14281.87	77.60	2.50
	JUN	5028.11	40.10	0.0	8747.83	13816.04	108.60	3.62
	JUL	4245.10	35.46	19.75	9856.09	14156.41	106.10	3.42
	AUG	4209.88	17.82	0.0	12744.49	16972.19	181.70	5.86
	SEP	5323.05	8.78	0.0	11718.45	17050.27	101.30	3.38
	OCT	5711.52	81.24	0.0	13041.93	18834.69	119.40	3.85
	NOV	2867.20	2419.67	0.0	12689.73	17976.60	628.40	20.95
	DEC	3308.00	2256.89	0.0	13500.73	19065.61	610.30	19.69
	TOTAL	52834.38	8436.77	19.75	126268.06	187559.00	3049.30	
1973	JAN	1526.32	3148.59	0.0	13701.33	18376.25	777.20	20.07
	FEB	3003.18	1405.77	0.0	11569.55	15978.50	378.10	13.50
	MAR	3221.90	1297.60	0.0	12461.45	16980.95	328.80	10.61
	APR	4385.15	252.64	0.0	11643.38	16281.17	127.30	4.26
	MAY	5309.98	177.40	0.0	11597.78	17085.17	123.70	3.99
	JUN	4303.67	16.87	0.0	13651.00	17971.54	111.80	3.73
	JUL	4934.91	5.90	0.0	13923.77	18864.58	90.30	2.91
	AUG	5285.06	6.67	0.0	12535.74	17827.46	66.20	2.14
	SEP	5955.56	13.16	0.0	11233.75	17202.47	71.20	2.37
	OCT	5617.25	211.88	0.0	12001.46	17830.59	124.40	4.01
	NOV	2379.45	2701.47	0.0	12011.83	17092.75	650.70	21.69
	DEC	2579.97	2607.58	0.0	12523.52	17711.06	587.70	18.96
	TOTAL	48502.41	11845.52	0.0	148854.56	209202.50	3437.40	9.42
1974	JAN	2287.15	3101.50	0.0	10714.77	16103.41	734.51	23.69
	FEB	2274.54	2477.19	0.0	10143.61	14895.33	585.45	20.91
	MAR	3903.02	965.09	0.0	10191.87	15059.98	235.89	7.61
	APR	4991.41	733.44	0.0	9742.18	15467.03	227.65	7.59
	MAY	5424.39	464.71	0.0	10848.32	16737.42	160.54	5.18
	JUN	4021.76	1064.20	0.0	10726.00	15811.96	278.24	9.27
	JUL	4603.53	276.25	0.0	12495.19	17374.98	134.81	4.35
	AUG	4886.24	69.40	0.0	11537.21	16492.86	99.96	3.22
	SEP	4579.84	56.86	0.0	11560.95	16197.65	113.53	3.78
	OCT	3721.19	995.91	0.0	11172.30	15889.39	323.51	10.44
	NOV	2441.74	1948.23	0.0	10908.56	15298.52	466.01	15.53
	DEC	1641.43	2603.00	0.0	11725.41	15969.84	629.90	20.32
	TOTAL	44776.23	14755.76	0.0	131766.38	191298.31	3990.00	10.93

for fuel burning activities at these oil refineries over the three years of interest. The principal fuel for powering refinery heaters and boilers is refinery gas derived from the recovered light ends of hydrocarbons being processed at the refineries. Natural gas was the second most abundant fuel, with fuel oil being used to supplement gaseous fuels, mostly during winter months when natural gas supplies were curtailed. Since the sulfur content of fuel oil is substantially greater than that of either natural gas or well-stripped refinery gas, SO_x emissions from refinery fuel have historically peaked in the winter months along with fuel oil use patterns.

Figures A2.6 and A2.7 display the geographic distribution of refinery fuel burning SO_x emissions for a typical summer and a typical winter month. As was the case with the power plants, the largest refineries are located adjacent to the coastline in an arc from El Segundo on the north to Long Beach on the south.

A2.2.3 Other Interruptible Gas Customers

During the period 1972 through 1974 large commercial/institutional and industrial gas customers enjoyed a relatively high level of natural gas service, as shown in Table A2.6. Historic fuel oil combustion SO_x emissions for these sources are thus very low. The California Public Utilities Commission, however, projects that increasingly severe shortages of natural gas will cause complete conversion of Southern California interruptible gas customers to the burning of alternate fuels by the year 1979 or 1980 (California Public Utilities Commission, 1976). Sulfur bearing fuel oils are

REFINERY FUEL SOX EMISSIONS FOR YEAR 1973 , MONTH 7 IN TONS/DAY AS SO2

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
24	0.C	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23	0.C	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22	0.C	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
19	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.C	C.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14	0.C	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	C.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.C	C.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

SOX TONS/DAY	FRACTION AS SO3
2.913	0.030

(July 1973)

FIGURE A2.6

REFINERY FUEL SOX EMISSIONS FOR YEAR 1973 , MONTH 1 IN TONS/DAY AS SO2

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
24	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
19	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12	0.0	0.0	0.0	0.0	0.0	0.0	3.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.2	0.0	0.0	4.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.4	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

RESEDA, BURBANK, GLENDALE, PASADENA, AZUSA, GLENDORA, WEST COVINA, WEST LA, LOS ANGELES, SANTA MONICA, LENNOX, LYNWOOD, TORRANCE, LONG BEACH, ANAHEIM, GARDEN GROVE, SANTA ANA

SOX TONS/DAY	FRACTION AS SO3
25.071	0.030

(January 1973)

FIGURE A2.7

TABLE A2.6

Natural Gas Curtailment
of Industrial Interruptible Gas Customers*
by Southern California Gas Company
1972 - 1974

Year	Industrial Interruptible Customer Requests for Service (MMCF/year)	Industrial Interruptible Gas Curtailed (MMCF/year)	Industrial Interruptible Gas Delivered (MMCF/year)	Deliveries as a Percentage of Requests for Service
1972	223,733	19,430	204,303	91%
1973	229,909	27,737	202,172	88%
1974	224,285	32,320	191,965	86%

*Including some petroleum refinery sales.
Source: 1975 California Gas Report

expected to be the principal substitute for the lost natural gas. A method for locating and characterizing energy demands by industrial and commercial interruptible gas customers is thus quite important for projection of future SO_x emission levels in Los Angeles.

A complete set of spatially resolved historial data on fuel burning by interruptible gas customers is simply unavailable. Therefore, a mathematical model was developed which is capable of simulating the SO_x emission impact of natural gas curtailment on the basis of a gas customer's known priority for obtaining natural gas.

Briefly, the modeling procedure is as follows. Complete data on the monthly fuel burning behavior of 134 major interruptible gas customers in Los Angeles County were copied from the files of the APCD. Data on the use of fuel oils, LPG and natural gas were obtained for these industries. When the sulfur content of fuel oil was not listed for a source in a given month, a value of 0.25% sulfur was used for distillate oil and a value of 0.40% sulfur was assumed if industrial residual fuel oil was being burned.

Next, a name and address list of nearly all of the interruptible gas customers in Los Angeles County was obtained (Zwiacher, 1976), grouped into five classes of interruption priority (curtailment blocks) based on source size. The 134 sources with complete fuel burning information were located on this list and grouped by curtailment block. Then monthly energy use and SO_x emissions were accumulated to the grid system for each individual source. The monthly fuel use, by fuel type, for the average of all sources in each curtailment block was computed and retained.

Next, partial data on recent fuel burning behavior were acquired from the files of the Southern California APCD for an additional 297 interruptible gas customers. In the case of Los Angeles County sources, this took the form of one summer month's data from 1974 and one winter month's data from 1975. In the case of Orange County sources, 1974 annual average data were acquired (Zwiacher, 1976). Average heat input at these sources was computed; they were assigned to their appropriate curtailment block and located geographically on the grid. Then historic 1972 through 1974 emissions for these sources were simulated under the following assumptions:

(1) Historic average heat input and oil type consumed by each source is well represented by observed recent behavior.

(2) The gas company is an impartial supplier who curtails all customers in the same curtailment block to the same degree at the same time.

Average heat input computed for each source in each curtailment block was modulated by a seasonal trend in energy use apparent from other sources in that curtailment block for which more complete information was available. Then, sources with partial information were modeled as if their heat input demands were met by the same relative combination of fuels in a given month as was observed to have been used by the average of all similarly sized sources for which complete fuel choice data were available.

Finally, heat input at each remaining source known to be interruptible but for which no specific fuel use data were available was catalogued as requiring thermal energy at a rate equal to the average of all sources in their curtailment block for which complete information was available. The simulation based on the average percentages of gas, LPG and oil use within a given curtailment block in a given month was again used to estimate fuel use and SO_x emissions for these sources on a monthly basis.

The results of this gas curtailment simulation are shown in Table A2.7. A double check on the calculation is available since non-refinery, non-utility interruptible gas deliveries to all such customers in Los Angeles and Orange Counties are known for the year 1974 (Wood, 1977). Based on demographic data available for 1974 from the California Department of Transportation (1975), it is found that the 50 by 50 mile square grid contains 96.8% of the total employment of Los Angeles and Orange Counties. Scaling non-refinery, non-utility interruptible customer gas send-out to those counties to the employment fraction within the 50 by 50 mile grid, and subtracting non-refinery gas exchange customers from our simulation results, we obtain the gas use comparison shown in Table A2.8. Our gas curtailment model reproduced total gas use by these customers to within 6.4 percent. This gives us some confidence that the geographic distribution of SO_x emissions (see Figures A2.8 and A2.9) and the total quantity of fuel oil burned is reasonably represented. Both of these pieces of information are otherwise unavailable for these years since the "energy balance" calculations presented in Appendix A3 of this report failed to balance well for distillate fuel oil. Furthermore, we now have a model which could predict the geographic distribution of fuel oil demand and SO_x emissions from these sources

TABLE A2.7

Fuel Burning Simulation Results for Other Interruptible Gas Customers Within the 50 by 50 Mile Grid
(electric utilities and refineries excluded)

YEAR	MONTH	HEAT INPUT BY FUEL TYPE (in 10^9 BTUs for each month) NATURAL GAS	FUEL OILS	LIQUFIED PETROLEUM GAS	TOTAL HEAT INPUT	SO_x EMISSIONS tons	tons/day
1972	JAN	10380.52	935.18	29.80	11345.50	172.22	5.56
	FEB	10678.30	225.46	33.95	10937.71	39.61	1.37
	MAR	10968.58	98.49	26.78	11093.84	18.90	0.61
	APR	11003.35	116.27	2.26	11121.87	22.51	0.75
	MAY	10832.01	111.29	2.48	10945.78	19.99	0.64
	JUN	10605.22	93.96	1.97	10701.14	20.17	0.67
	JUL	9857.30	66.92	2.35	9926.56	12.01	0.39
	AUG	9978.08	97.99	2.61	10078.67	19.44	0.63
	SEP	10427.25	69.70	2.89	10499.84	15.31	0.51
	OCT	10626.89	96.45	2.97	10726.30	18.22	0.59
	NOV	10688.20	383.70	2.64	11074.54	82.20	2.74
	DEC	7927.18	2632.59	256.24	10816.00	411.91	13.29
	TOTAL	123972.88	4928.00	366.94	129267.75	852.49	2.33
1973	JAN	9174.14	2532.18	302.44	12008.76	396.19	12.78
	FEB	10524.09	309.49	28.53	10862.11	62.84	2.24
	MAR	10625.62	293.98	15.01	10934.61	64.21	2.07
	APR	10925.26	137.84	12.18	11075.28	29.41	0.98
	MAY	10816.45	115.48	3.40	10935.33	25.25	0.81
	JUN	10242.52	41.57	3.14	10287.23	11.63	0.39
	JUL	9969.38	44.84	4.39	10018.61	11.99	0.39
	AUG	9673.88	49.00	4.31	9727.20	12.51	0.40
	SEP	10166.04	50.09	3.38	10219.51	12.80	0.43
	OCT	10246.13	108.31	3.21	10357.65	23.60	0.76
	NOV	9746.39	523.81	74.57	10344.77	107.37	3.58
	DEC	9337.55	399.60	78.67	9815.82	79.72	2.57
	TOTAL	121477.45	4606.19	533.23	126586.88	837.52	2.29
1974	JAN	8259.16	1527.89	103.91	9890.97	257.26	8.30
	FEB	9772.72	199.42	5.16	9977.30	44.98	1.61
	MAR	9782.82	133.62	2.38	9918.81	29.12	0.94
	APR	9594.05	95.17	2.73	9691.94	21.28	0.71
	MAY	9459.71	102.34	2.96	9565.01	21.49	0.69
	JUN	9293.45	149.72	3.40	9446.56	31.46	1.05
	JUL	9152.30	86.25	3.17	9241.73	19.81	0.64
	AUG	9332.33	88.62	1.57	9422.51	18.27	0.59
	SEP	9856.30	79.42	0.00	9935.73	16.19	0.54
	OCT	9891.12	149.16	2.49	10042.77	34.66	1.12
	NOV	9966.27	277.14	9.13	10252.54	61.21	2.04
	DEC	9219.50	517.80	28.10	9765.40	115.38	3.72
	TOTAL	113579.73	3406.55	165.00	117151.27	671.11	1.84

TABLE A2.8

Comparison of Interruptible Gas Use Simulation
to Gas Company Deliveries to these Customers: 1974

			10^9 BTUs	10^9 BTUs
A.	Simulation Model - 1974			
	1. total gas use in 50 x 50 mile square by non-utility, non-refinery interruptible customers		113,579.73	
	2. less non-refinery exchange customers and process gas included in this model		(-) 7,866.60	
	3. Industrial/Commercial/Institutional use excluding refineries and exchange customers		105,713.13	105,713.13
B.	Actual Gas Company Deliveries - 1974			
	1. Industrial/Commercial/Institutional interruptible send-out excluding refineries and exchange customers in two counties			
	(a) So. California Gas Company	MCF		
	Los Angeles County	75,133,434		
	Orange County	17,979,105		
	(b) Long Beach Gas Department	3,721,671		
	Subtotal (MCF)	96,834,210		
	Energy Content (10^9 BTUs)		102,644.26	
	2. Scale total use to the 96.8% of L.A. and Orange County employment within 50 by 50 mile square			
	$(102,644.26 \times 10^9) \cdot (0.968) =$		99,359.64	
	3. Industrial/Commercial/Industrial use excluding refineries and exchange customers			99,359.64
C.	Excess of simulation model over actual			(6.4%)

OTHER INTERRUPTIBLE GAS CUSTOMER SOX EMISSICAS FCR YEAR 1973 , MONTH 7 IN TONS/DAY AS SO2

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
25	0.0	0.0	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
24	0.0	0.00	0.00	0.00	0.00	0.0	0.0	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23	0.00	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22	0.0	0.00	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21	0.0	0.0	0.0	0.0	0.0	0.00	0.0	0.00	0.00	0.00	0.00	0.00	0.0	0.0	0.00	0.0	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.00	0.0	0.0	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.0
19	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0C	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.0	0.0	0.00	0.00	0.00	0.00	0.0	0.0	0.00
18	0.0	0.0	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.0	0.0	0.00	0.0	0.0	0.01
17	0.0	0.0	0.0	0.0	0.00	0.00	0.01	0.00	0.0	0.00	0.00	0.01	0.00	0.00	0.00	0.0	0.00	0.0	0.00	0.0	0.0	0.0	0.0	0.00	0.00
16	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.0
15	0.0	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.0	0.0	0.00	0.0	0.0	0.0	0.0
14	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.00	0.0	0.01	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.0	0.00	0.00	0.00	0.0	0.0
12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.0	0.0	0.00	0.0	0.00	0.00	0.0
11	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.0
10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.19	0.00	0.00	0.00	0.00	0.00	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.0
9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0C	0.00	0.0	0.00
8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.02	0.00	0.00	0.0	0.00	0.00	0.0	0.0	0.00	0.0	0.00	0.00	0.00	0.00
7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.0	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.00	0.0	0.0	0.0	0.00	0.0	0.0	0.00	0.00	0.0
5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0	0.00	0.0	0.01	0.00	0.0
4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0	0.00	0.0	0.0	0.0	0.0
3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.00	0.0	0.0	0.00	0.0
2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0	0.0	0.0
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

SOX TONS/DAY	FRACTION AS SO3
0.387	0.030

(July 1973)

FIGURE A2.8

OTHER INTERRUPTIBLE GAS CUSTOMER SOX EMISSIONS FOR YEAR 1973 , MONTH 1 IN TONS/DAY AS SO2

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
25	0.0	0.0	0.0	0.0	0.0	0.01	0.00	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
24	0.0	0.00	0.00	0.04	0.00	0.0	0.0	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23	0.0C	0.0	0.0	0.00	0.11	0.00	0.01	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22	0.0	0.01	0.0	0.0	0.0	0.01	0.00	0.01	0.03	0.04	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21	0.0	0.0	0.0	0.0	0.0	0.00	0.0	0.00	0.01	0.01	0.01	0.00	0.0	0.0	0.00	0.0	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.01	0.0	0.08	0.00	0.01	0.02	0.07	0.0	0.0	0.0	0.00	0.0	0.03	0.0	0.00	0.0	0.0
19	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.02	0.03	0.01	0.02	0.00	0.0	0.00	0.02	0.0	0.0	0.00	0.02	0.00	0.00	0.0	0.0	0.00
18	0.0	0.0	0.0	0.0	0.0	1.26	0.01	0.01	0.02	0.02	0.02	0.03	0.16	0.01	0.01	0.0	0.01	0.05	0.00	0.0	0.0	0.00	0.0	0.0	1.50
17	0.0	0.0	0.0	0.0	0.00	0.07	0.17	0.00	0.0	0.02	0.06	0.31	0.01	0.00	0.00	0.0	0.00	0.0	0.03	0.0	0.0	0.0	0.0	0.04	0.00
16	0.0	0.0	0.0	0.00	0.00	0.03	0.00	0.01	0.01	0.00	0.03	0.43	0.20	0.28	0.04	0.00	0.01	0.00	0.03	0.00	0.00	0.05	0.03	0.0	0.0
15	0.0	0.0	0.0	0.0	0.00	0.00	0.02	0.00	0.00	0.02	0.11	0.87	0.69	0.27	0.29	0.00	0.00	0.00	0.0	0.0	0.01	0.0	0.0	0.0	0.0
14	0.0	0.0	0.0	0.0	0.0	0.0	0.01	0.01	0.01	0.0	0.00	0.80	0.25	0.09	0.00	0.0	0.20	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.02	0.05	0.0	0.00	0.08	0.01	0.02	0.02	0.00	0.04	0.00	0.0	0.0	0.01	0.01	0.00	0.0	0.0
12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.02	0.01	0.0	0.01	0.01	0.05	0.02	0.0	0.00	0.03	0.03	0.0	0.0	0.01	0.0	0.00	0.00	0.0
11	0.0	0.0	0.0	0.0	0.0	0.0	0.01	0.0	0.0	0.06	0.01	0.00	0.01	0.02	0.00	0.0	0.00	0.01	0.01	0.17	0.01	0.08	0.03	0.00	0.0
10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.02	0.69	0.01	0.08	0.02	0.00	0.00	0.0	0.0	0.0	0.00	0.00	0.02	0.01	0.00	0.00	0.0
9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.11	0.00	0.21	0.0	0.00	0.00	0.0	0.02	0.0	0.00	0.0	0.02	0.02	0.01	0.0	0.00
8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.23	0.08	0.01	0.0	0.01	0.00	0.0	0.0	0.00	0.0	0.01	0.01	0.00	0.00
7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.17	0.11	0.02	0.0	0.0	0.0	0.0	0.05	0.03	0.00	0.00	0.00	0.04	0.01	0.0
6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.24	0.00	0.0	0.0	0.0	0.00	0.0	0.0	0.0	0.00	0.0	0.0	0.05	0.00	0.0
5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0	0.01	0.0	0.16	0.00	0.0
4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0	0.02	0.0	0.0	0.0	0.0
3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.04	0.00	0.0	0.0	0.00	0.0
2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0	0.0	0.0
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.C	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

RESEDA, BURBANK, GLENDALE, PASADENA, AZUSA, GLENDORA, WEST COVINA, WEST LA, LOS ANGELES, SANTA MONICA, LENNOX, LYNWOOD, TORRANCE, LONG BEACH, ANAHEIM, GARDEN GROVE, SANTA ANA

SOX TONS/DAY	FRACTION AS SO3
12.780	0.030

(January 1973)

FIGURE A2.9

under anticipated 1980 conditions of complete gas curtailment.

A2.2.4 Firm Natural Gas Customers

Firm natural gas customers have the highest priority for receiving a steady gas supply. These sources are usually not equipped to burn oil as a substitute fuel. Since gas is clean-burning, historic SO_x emissions from these sources have been extremely low, averaging about a third of a ton per day of SO_x within the 50 by 50 mile grid.

Data on firm natural gas use in Los Angeles and Orange Counties for each month of the years 1972 through 1974 were provided by the California Air Resources Board (Wood, 1977) from Southern California Gas Company and Long Beach Gas Department reports. From this data base, domestic use and non-utility non-refinery firm industrial/commerical gas uses were isolated. The industrial/commercial gas use for each month was assigned to the grid system in proportion to estimated 1974 industrial employment within each square, while domestic gas use was allocated by estimated 1974 population density. Employment and population densities were estimated from data supplied by the California Department of Transportation (1975). This demographic data base consisted of maps showing Los Angeles Regional Transportation Study (LARTS) regional analysis zones, along with 1974 estimates of population and employment statistics within each zone. Large LARTS regional analysis zone maps were overlayed with our 50 by 50 mile grid system, and the portion of each regional analysis zone falling within each grid square was estimated graphically. Population and employment data were apportioned to the grid system on the basis of the fraction of each regional analysis zone falling in a given square. The results are shown in Figures A2.10 and A2.11.

A2.2.5 Total Non-Utility Fuel Combustion Emissions

For air quality modeling purposes, emissions from all non-utility fuel combustion activities will be superimposed to form a single source class. When this is done, the time history of monthly refinery, other interruptible and firm gas user SO_x emissions within the 50 by 50 mile square is as shown in Figure A2.12.

A2.3 Chemical Plant Emissions

Sulfur oxides emissions from chemical plant operations have declined drastically during the three year period of this emissions inventory, as shown in Figure A2.13. The source classes used to describe chemical plant emissions are:

- Sulfur Recovery Plants
- Sulfuric Acid Plants
- Miscellaneous Chemical Operations

A2.3.1 Sulfur Recovery Plants

During the year 1973, the feedstock and fuels supplied to Los Angeles area refineries contained an average of 3.7 million pounds per day of elemental sulfur bound within hydrocarbon chains (Southern California Air Pollution Control District, 1976a). As a result of the refining process, about 54 percent of this incoming sulfur burden is converted to gaseous hydrogen sulfide. If this

1974 POPULATION IN THOUSANDS

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
25	1.	21.	29.	25.	14.	28.	20.	13.	4.	6.	7.	3.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
24	0.	0.	14.	23.	21.	28.	22.	8.	5.	8.	8.	0.	2.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
23	11.	12.	17.	27.	21.	32.	28.	18.	9.	12.	3.	1.	11.	5.	4.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
22	17.	20.	22.	24.	25.	29.	28.	26.	16.	17.	12.	28.	21.	11.	23.	13.	2.	2.	0.	0.	0.	0.	0.	0.	0.
21	15.	17.	16.	16.	20.	25.	25.	28.	30.	28.	33.	40.	5.	12.	25.	20.	16.	14.	10.	9.	2.	0.	9.	3.	0.
20	1.	5.	9.	9.	10.	11.	15.	18.	20.	24.	22.	21.	12.	17.	21.	21.	21.	25.	32.	10.	8.	15.	39.	21.	5.
19	1.	1.	0.	0.	1.	8.	8.	31.	29.	45.	27.	26.	29.	31.	27.	22.	25.	28.	10.	15.	14.	12.	4.	7.	10.
18	1.	2.	0.	4.	14.	22.	19.	43.	33.	59.	51.	33.	33.	33.	30.	30.	23.	22.	14.	31.	28.	25.	11.	8.	11.
17	1.	4.	10.	12.	39.	39.	39.	38.	31.	57.	57.	27.	49.	50.	27.	26.	20.	17.	16.	23.	16.	11.	10.	12.	6.
16	0.	0.	0.	9.	39.	38.	39.	38.	36.	55.	46.	26.	32.	38.	16.	18.	19.	15.	15.	21.	13.	9.	9.	9.	0.
15	0.	0.	0.	0.	15.	35.	29.	31.	34.	50.	31.	27.	30.	19.	14.	22.	18.	18.	18.	19.	12.	8.	3.	10.	0.
14	0.	0.	0.	0.	0.	22.	15.	25.	37.	45.	50.	48.	43.	39.	29.	23.	16.	22.	17.	14.	9.	0.	1.	4.	0.
13	0.	0.	0.	0.	0.	4.	17.	17.	39.	40.	45.	38.	35.	32.	26.	27.	18.	20.	14.	18.	18.	16.	0.	0.	0.
12	0.	0.	0.	0.	0.	0.	26.	27.	36.	37.	26.	26.	27.	31.	31.	30.	25.	16.	15.	19.	17.	16.	13.	4.	7.
11	0.	0.	0.	0.	0.	0.	12.	35.	32.	31.	26.	22.	26.	34.	31.	28.	30.	17.	16.	22.	15.	13.	14.	9.	11.
10	0.	0.	0.	0.	0.	0.	5.	27.	22.	21.	21.	11.	18.	25.	33.	30.	27.	21.	21.	26.	23.	23.	19.	10.	4.
9	0.	0.	0.	0.	0.	0.	1.	32.	24.	23.	20.	12.	27.	20.	19.	19.	25.	33.	29.	37.	24.	21.	20.	21.	6.
8	0.	0.	0.	0.	0.	0.	1.	9.	22.	20.	14.	15.	26.	44.	35.	26.	27.	30.	28.	30.	29.	33.	13.	19.	12.
7	0.	0.	0.	0.	0.	0.	7.	7.	2.	11.	14.	10.	6.	9.	22.	20.	13.	16.	19.	27.	30.	35.	47.	30.	12.
6	0.	0.	0.	0.	0.	0.	7.	10.	13.	31.	12.	0.	0.	0.	0.	3.	13.	21.	19.	22.	20.	34.	15.	5.	2.
5	0.	0.	0.	0.	0.	0.	1.	1.	5.	3.	1.	0.	0.	0.	0.	0.	6.	21.	20.	25.	13.	12.	8.	2.	7.
4	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	7.	20.	20.	2.	9.	10.	1.	2.
3	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	5.	19.	18.	20.	10.	2.	0.
2	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	10.	17.	5.	0.	0.
1	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	2.	0.	0.

TOTAL POPULATION = 8139.2 THOUSAND PERSONS

FIGURE A2.10

1974 EMPLOYMENT IN THOUSANDS

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
25	0.	9.	9.	5.	3.	6.	5.	3.	1.	1.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
24	0.	0.	4.	6.	10.	11.	6.	2.	2.	1.	1.	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
23	3.	3.	4.	6.	15.	20.	10.	12.	7.	12.	2.	1.	5.	2.	3.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
22	11.	15.	8.	6.	15.	18.	12.	11.	17.	18.	8.	6.	6.	5.	14.	6.	1.	1.	0.	0.	0.	0.	0.	0.	0.
21	4.	8.	4.	3.	10.	15.	9.	9.	19.	18.	19.	15.	1.	8.	15.	10.	6.	5.	3.	3.	0.	0.	2.	1.	0.
20	0.	1.	2.	2.	2.	4.	5.	5.	6.	10.	10.	10.	4.	9.	12.	8.	7.	7.	8.	3.	9.	11.	8.	5.	1.
19	0.	0.	0.	0.	0.	3.	3.	14.	28.	29.	12.	11.	10.	12.	10.	7.	6.	7.	3.	4.	5.	4.	2.	3.	4.
18	0.	0.	0.	1.	4.	19.	21.	38.	30.	41.	41.	24.	14.	10.	11.	8.	9.	10.	5.	9.	9.	9.	4.	4.	9.
17	0.	1.	2.	3.	19.	40.	34.	25.	22.	33.	135.	163.	29.	12.	6.	7.	10.	9.	5.	6.	6.	4.	1.	8.	7.
16	0.	0.	0.	3.	32.	14.	14.	13.	9.	14.	101.	60.	31.	16.	18.	18.	8.	7.	5.	6.	4.	1.	1.	1.	0.
15	0.	0.	0.	0.	4.	11.	15.	10.	11.	13.	10.	28.	26.	15.	19.	7.	7.	7.	5.	6.	5.	3.	0.	1.	0.
14	0.	0.	0.	0.	0.	9.	21.	15.	14.	13.	17.	19.	14.	12.	10.	10.	8.	6.	4.	3.	2.	0.	0.	0.	0.
13	0.	0.	0.	0.	0.	2.	19.	33.	13.	13.	15.	12.	11.	9.	16.	11.	7.	6.	3.	7.	6.	3.	0.	0.	0.
12	0.	0.	0.	0.	0.	0.	10.	17.	14.	15.	9.	9.	9.	10.	14.	8.	6.	7.	4.	8.	11.	5.	2.	1.	1.
11	0.	0.	0.	0.	0.	0.	4.	14.	12.	15.	10.	9.	9.	10.	9.	6.	6.	5.	9.	10.	13.	13.	8.	3.	2.
10	0.	0.	0.	0.	0.	0.	2.	12.	13.	10.	8.	6.	7.	9.	9.	7.	4.	4.	8.	11.	11.	12.	11.	2.	1.
9	0.	0.	0.	0.	0.	0.	0.	10.	7.	8.	8.	7.	12.	11.	11.	11.	5.	4.	7.	9.	20.	19.	9.	4.	1.
8	0.	0.	0.	0.	0.	0.	0.	2.	5.	8.	9.	13.	23.	20.	13.	6.	4.	4.	8.	8.	9.	24.	9.	3.	5.
7	0.	0.	0.	0.	0.	0.	1.	1.	0.	10.	13.	17.	12.	3.	7.	7.	5.	5.	4.	5.	9.	21.	19.	9.	5.
6	0.	0.	0.	0.	0.	0.	1.	1.	1.	8.	5.	0.	0.	0.	0.	1.	5.	4.	3.	3.	5.	12.	9.	2.	2.
5	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	0.	0.	0.	0.	0.	0.	1.	4.	3.	2.	5.	6.	6.	2.	3.
4	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	3.	1.	2.	9.	9.	1.	2.
3	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	6.	10.	11.	5.	1.	0.
2	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	8.	12.	3.	0.	0.
1	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	1.	0.	0.

RESEDA
BURBANK
GLENDALE
PASADENA
AZUSA
GLENDORA
WEST COVINA
WEST LA
LOS ANGELES
SANTA MONICA
LENNOX
LYNWOOD
TORRANCE
LONG BEACH
ANAHEIM
GARDEN GROVE
SANTA ANA

TOTAL EMPLOYMENT = 3892.1 THOUSAND PERSONS

FIGURE A2.11

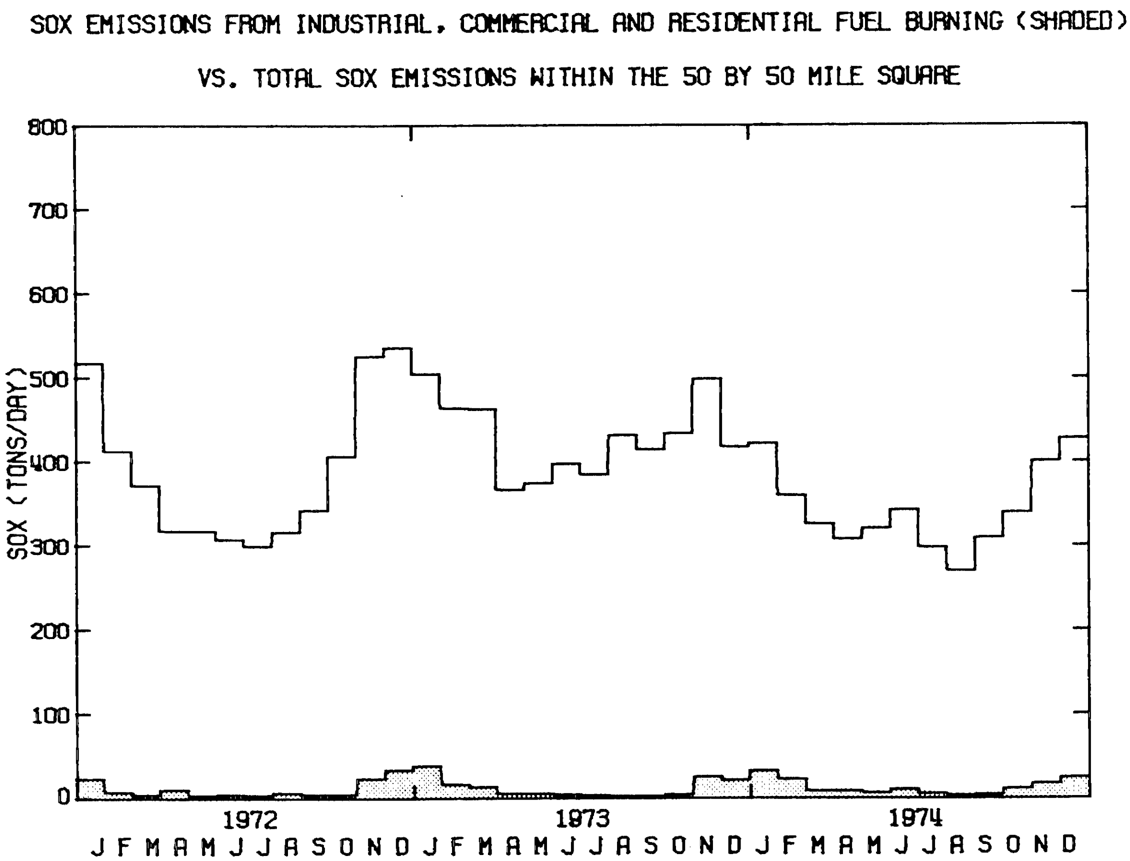

SOX EMISSIONS FROM INDUSTRIAL, COMMERCIAL AND RESIDENTIAL FUEL BURNING (SHADED)
VS. TOTAL SOX EMISSIONS WITHIN THE 50 BY 50 MILE SQUARE
SOX (TONS/DAY)
800
700
600
500
400
300
200
100
0
1972
1973
1974
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D

FIGURE A2.12

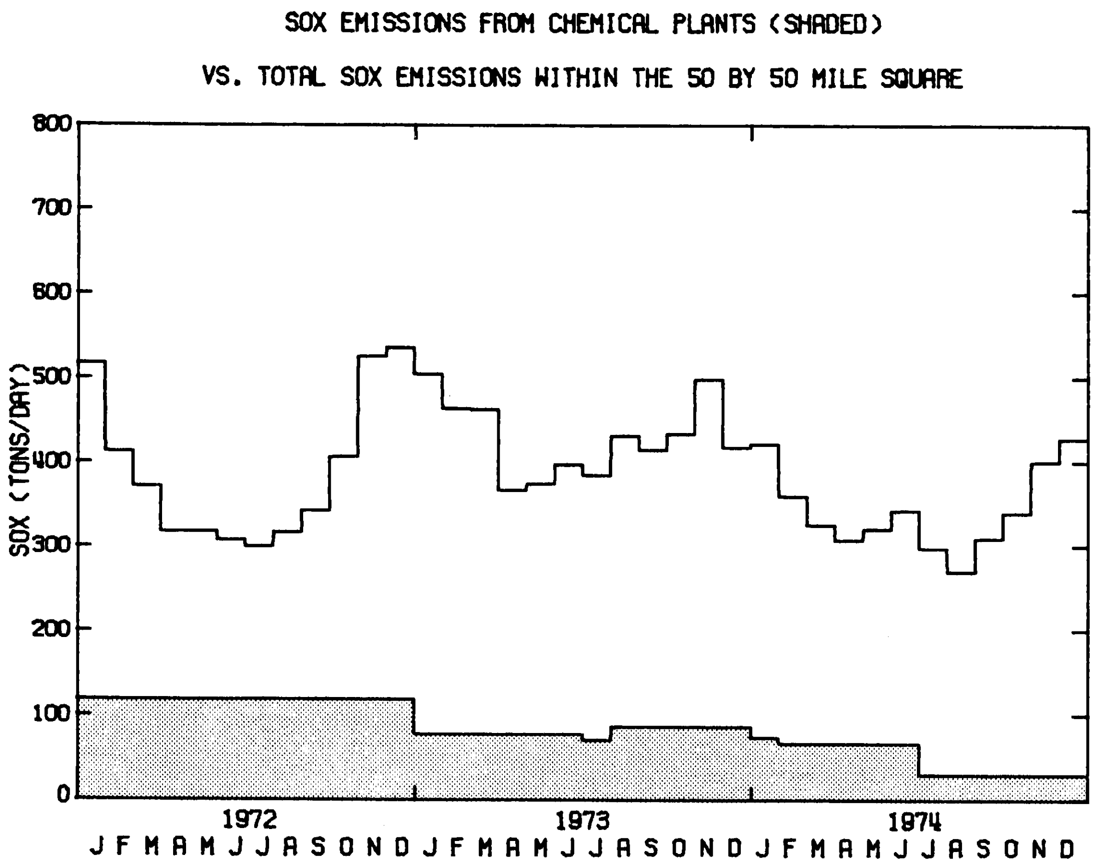

SOX EMISSIONS FROM CHEMICAL PLANTS (SHADED)
VS. TOTAL SOX EMISSIONS WITHIN THE 50 BY 50 MILE SQUARE
SOX (TONS/DAY)
800
700
600
500
400
300
200
100
0
1972
1973
1974
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D

FIGURE A2.13

hydrogen sulfide was left in refinery fuel gases or incinerated to form SO_2 and released to the atmosphere from refinery flare stacks, the resulting SO_x emissions would have totaled nearly 2000 tons per day (as SO_2) in that year. In that event, total SO_x emissions within the 50 by 50 mile grid would have been about five times higher than was the case during the year 1973.

In order to prevent this sulfur release to the atmosphere, hydrogen sulfide is stripped from refinery gas streams by amine absorption units. After being concentrated, most of the H_2S is then ducted to Claus sulfur recovery plants. Sulfuric acid manufacturing plants are also used to process some of this hydrogen sulfide waste gas.

The Claus sulfur recovery plants operated in the Los Angeles basin prior to 1973 were about 90% to 95% efficient at converting H_2S to elemental sulfur (Hunter and Helgeson, 1976). As refinery capacity and complexity increased over the years, the quantity of H_2S generated increased. This lead to a corresponding growth in atmospheric emissions from sulfur recovery plant exhaust. By the start of 1971, sulfur recovery and sulfuric acid plant emissions totaled 116 tons of SO_2 per day (almost half of the total SO_x emissions in Los Angeles County at that time (Lemke, et al., 1971).

To limit sulfur recovery plant emissions further, the LAAPCD adopted emission control regulations which in effect required that Claus plants be equipped with tail gas clean-up units. The impact of this emission control policy change was not felt simultaneously at all refineries. The first tail gas units went on-line at the beginning of 1973. Throughout the years 1973 and 1974 sulfur recovery plant tail gas units at additional refineries began operation. Total SO_x emissions from the phased installation of tail gas clean-up systems appear as shown in Tables A2.14 through A2.16 in the summary to this appendix.

Sulfur balances on the basin's oil refineries and chemical plants have been computed by APCD engineers for the years 1973 and 1974 (Southern California Air Pollution Control District, 1976a). These sulfur balances include atmospheric emissions estimates for each major type of chemical or refinery process at each facility. The mass balance approach provides reasonable assurance that atmospheric emissions estimates are consistent with total refinery sulfur intake on a year-round basis. In all but two cases, individual source estimates used to compile the time history of sulfur recovery plant emissions reported in our inventory were based on the APCD's sulfur balances entitled "Sulfur Recovery and Sulfuric Acid Plant Operations -- Los Angeles County", 1973 and 1974 editions. Discussions with APCD engineers were used to estimate the date of startup of new equipment items, and the magnitude of emissions before and after the change in equipment. In general, January 1973 emissions derived from the APCD chemical plant sulfur balances were carried backward to represent source emissions during 1972. An exception to this procedure had to be made in the case of 1972 SO_x emissions from the Allied Chemical/Standard Oil sulfur recovery complex. At the close of 1972, the old sulfur plant in question was abandoned. Historic files on this source have been discarded by the APCD. SO_x emissions for the abandoned facility were thus estimated on the basis of 1973 annual average sulfur throughput at the new Standard Oil sulfur plant, combined with Hunter and Helgeson's (1976) uncontrolled Claus plant source test result of 333 pounds of SO_x per ton of sulfur processed. Hunter and Helgeson's source test data were also used to compute emissions from the new ARCO sulfur recovery plant prior to completion of its tail gas clean-up system.

By December 1974, SO_x emissions from Claus sulfur recovery plants had been reduced to 25.8 tons per day from a January 1972 level of about 93.5 tons per day. At least two refineries were still experiencing operating trouble with their new tail gas units at the end of 1974. Once those sources are corrected, SO_x emissions from sulfur recovery plants should drop to about 3 tons per day.

The spatial distribution of SO_x emissions from sulfur recovery plants for mid-1974 is shown in Figure A2.14, as compared to an estimate for January 1972 in Figure A2.15. A substantial change in the spatial distribution of emissions occurred during our study period. Most of these spatial changes in emission strength are due to imposition of emission controls. In addition, certain refineries whose effluent was once processed by outside chemical contractors decided to build their own sulfur recovery plants at another location.

SULFUR RECOVERY SOX EMISSIONS FOR YEAR 1974 , MONTH 7 IN TONS/DAY AS SO2

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
24	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
19	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12	0.0	0.0	0.0	0.0	0.0	0.0	0.38	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.04	0.0	0.0	3.16	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.22	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20.82	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.01	0.07	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

SOX TONS/DAY	FRACTION AS SO3
25.838	0.004

(July 1974)

FIGURE A2.14

SULFUR RECOVERY SOX EMISSIONS FOR YEAR 1972 , MONTH 1 IN TONS/DAY AS SO2

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
24	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
19	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.06	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	36.63	0.0	0.0	0.0	0.0	0.0	0.0	0.04	0.0	0.0	2.55	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	46.80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.39	0.06	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

RESEDA, BURBANK, GLENDALE, PASADENA, AZUSA, GLENDORA, WEST COVINA, WEST LA, LOS ANGELES, SANTA MONICA, LENNOX, LYNWOOD, TORRANCE, LONG BEACH, ANAHEIM, GARDEN GROVE, SANTA ANA

SOX TONS/DAY	FRACTION AS SO3
93.530	0.004

(January 1972)

FIGURE A2.15

A2.3.2 Sulfuric Acid Plants

Sulfuric acid production is the second type of industrial process used to recover sulfur from refinery wastes. Five contact process acid plants are operated at three plant sites in Los Angeles County. These plants consumed a variety of feed stocks. During the year 1973, for example, sulfuric acid production consumed the equivalent of 480 tons per day of elemental sulfur. About 38 percent of this sulfur input came from reprocessing acid sludge, 44 percent from burning elemental sulfur, and 18 percent from burning hydrogen sulfide (Southern California Air Pollution Control District, 1976a).

During the period of this emission inventory, sulfuric acid plant emissions were substantially reduced through the installation of additional control equipment. Sulfur oxides emissions of at least 25 tons per day in 1971 (Lemke, et al, 1971) were reduced to 3.12 tons per day during 1974 (Southern California Air Pollution Control District, 1976a). The spatial distribution of sulfuric acid plant emissions for a summer month in 1974 is given in Figure A2.16. The previously mentioned APCD chemical plant sulfur balances were the basis for all emissions estimates made, except for emissions from the Allied Chemical/Standard Oil complex acid plant during the year 1972. Pre-1973 emissions at that abandoned plant were estimated by taking January 1973 emissions from acid plants not connected with the Standard Oil refinery and subtracting those emissions from Los Angeles County total acid plant SO_x emissions of 25 tons per day in 1971 as reported by Lemke, et al. (1971).

SULFURIC ACID PLANT SOX EMISSIONS FOR YEAR 1974 , MONTH 7 IN TONS/DAY AS SO2

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
24	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.C	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
19	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.C	0.0	0.0	0.0	0.C	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.C	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12	0.0	0.0	0.0	0.0	0.0	0.0	0.20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.C	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.72	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.C	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

RESEDA
BURBANK
GLENDALE
PASADENA
AZUSA
GLENDORA
WEST COVINA
WEST LA
LOS ANGELES
SANTA MONICA
LENNOX
LYNWOOD
TORRANCE
LONG BEACH
ANAHEIM
GARDEN GROVE
SANTA ANA

SOX TONS/DAY	FRACTION AS SO3
3.120	0.0[illegible]

(July 1974)

FIGURE A2.16

A2.3.3 Miscellaneous Chemical Operations

About 0.09 tons per day of SO_x are emitted from other industrial operations employing chemicals. These include detergent manufacturing and one glass bottle factory which finishes some of their products by exposing them to sulfur dioxide gas.

A2.4 Emissions from Petroleum Refining and Production

Total inventoried emissions from petroleum refinery processes and oil field operations are shown in time series in Figure A2.17, along with total SO_x emissions within the 50 by 50 mile square grid. The geographic distribution of emission sources is given in Figure A2.18 for a typical day in 1973. For the purpose of this discussion, the source classes used to represent SO_x emissions from petroleum refining and production are:

- Fluid Catalytic Crackers
- Other Refinery Process Equipment
- Oil Field Production Operations

A2.4.1 Fluid Catalytic Crackers

The vast bulk of refinery industrial process SO_x emissions in the South Coast Air Basin originate from eight fluid catalytic cracking units (FCCU) at refineries within the 50 by 50 mile grid. The purpose of these devices is to break large hydrocarbon molecules contained in gas oils down into lighter molecules suitable for blending into the gasoline pool. The heavy hydrocarbons introduced into the FCCUs are accompanied by bound sulfur which tends to accumulate in a coke layer formed over the surface of the cracker's

SOX EMISSIONS FROM PETROLEUM REFINING AND PRODUCTION (SHADED)

VS. TOTAL SOX EMISSIONS WITHIN THE 50 BY 50 MILE SQUARE

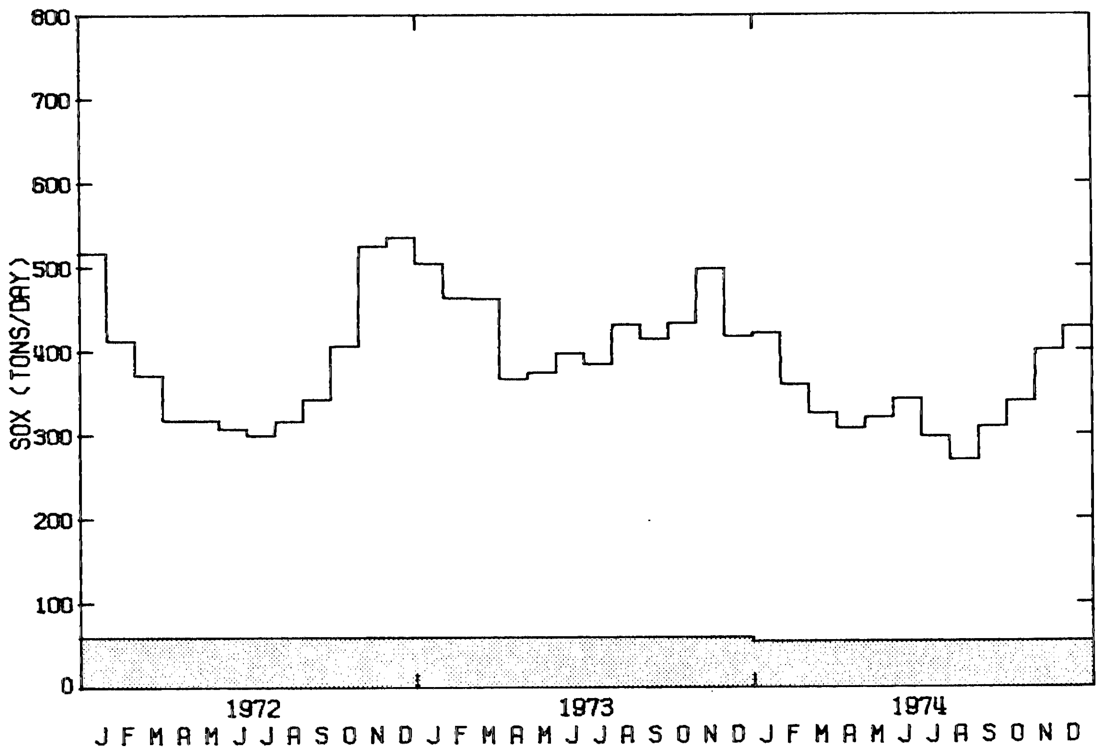


FIGURE A2.17

PETROLEUM PROCESSING EMISSIONS FOR 1973 IN TONS PER DAY OF SOX STATED AS SO2

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
24	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
19	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.06	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.03	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.90	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12	0.0	0.0	0.0	0.0	0.0	0.0	11.14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.70	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.70	0.0	0.0	5.52	0.0	0.C	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.01	8.32	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.00	3.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.50	0.0	0.0	0.0	0.0	0.0
2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

RESEDA, BURBANK, GLENDALE, PASADENA, AZUSA, GLENDORA, WEST COVINA, WEST LA, LOS ANGELES, SANTA MONICA, LENNOX, LYNWOOD, TORRANCE, LONG BEACH, ANAHEIM, GARDEN GROVE, SANTA ANA

SOX
TONS/DAY
59.999

FIGURE A2.18

catalyst charge. In order to regenerate the catalyst material, this coke layer is burned off, releasing the sulfur to the atmosphere.

Figure A2.19 shows the geographic distribution of FCCU emissions for a typical day during the year 1973. These data are taken from the Southern California APCD's "Sulfur Balance - Los Angeles County Refineries", 1973 and 1974 editions (Southern California Air Pollution Control District, 1976a). Recent source tests reported by Hunter and Helgeson (1976) placed average 1974 FCCU emissions at 45.56 tons per day, which compares very favorably to the APCD's value of 45.48 tons per day for that year. The APCD's average daily values will be used for each day of 1973 and 1974, and the 1973 data will be assumed to represent 1972 as well.

A2.4.2 Other Refinery Process Equipment

In addition to the 45.5 tons per day of SO_x emitted from fluid catalytic cracking in 1974, there were smaller but non-negligible SO_x emissions from at least 37 pieces of other refinery process equipment. Emissions from these miscellaneous equipment items averaged 3.43 tons per day in 1973 and 4.17 tons per day in 1974. The most significant SO_x sources involved include delayed coker blow-down units, and sour water strippers which are listed separately in Tables A2.14 through A2.16 in the summary to this appendix.

Emissions from sour water strippers, caustic regeneration, and SO_2 treating operations were taken from the APCD sulfur balance summaries. Additional equipment items not specified in the sulfur balance but identified in the APCD permit file were included in the

REFINERY CAT CRACKER SOX EMISSIONS FOR YEAR 1973 IN TONS/DAY AS SO2

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
24	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
19	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.90	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12	0.0	0.0	0.0	0.0	0.0	0.0	10.70	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.34	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.73	0.0	0.0	5.50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.00	2.90	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

RESEDA
BURBANK
GLENDALE
PASADENA
AZUSA
GLENDORA
WEST COVINA
WEST LA
LOS ANGELES
SANTA MONICA
LENNOX
LYNWOOD
TORRANCE
LONG BEACH
ANAHEIM
GARDEN GROVE
SANTA ANA

SOX TONS/DAY	FRACTION AS SO3
52.070	0.028

FIGURE A2.19

inventory at their permit file SO_x emission rate. This later group of equipment included emissions from delayed coker blow-down units at two refineries. Additional refineries in the Los Angeles area have coking facilities (see Cantrell, 1973). There may be emissions from other blow-down units of which we are not aware, unless these units are connected directly to sulfur recovery plants at all times during the coking cycle.

A2.4.3 Oil Field Production Operations

Fire flooding used to stimulate oil production at one Newport Beach area oil field results in generation of H_2S-containing exhaust gases. These sour gases are subsequently burned in a group of fume incinerators as a means of preventing the H_2S from reaching the atmosphere (Hunter and Helgeson, 1976). Historic SO_x emission data for these sources provided by the Southern California APCD-Southern Zone will be used in this study as indicated in Table A2.9. The 5.17 tons per day value given in that table for 1974 compares fairly closely with Hunter and Helgeson's estimated 1974 emissions from these sources of 5.4 tons per day of SO_x.

A2.5 Miscellaneous Stationary Sources

This miscellaneous stationary source category includes SO_x emissions from materials fabrication processes and from waste disposal. The source classes used to represent miscellaneous stationary sources are:

- Petroleum Coke Calcining Kilns
- Glass Furnaces

TABLE A2.9

SO_x Emissions from Oil Field Production Activities in the Vicinity of Newport Beach

Year	Oil Field Operation SO_x Emissions (tons/day)
1972	4.0
1973	4.5
1974	5.17

Reference: Records of the Southern California APCD - Southern Zone (Kaye, 1976).

- Metals Processing Plants
- Mineral Processing Plants
- Sewage Treatment Plants
- Miscellaneous Industries
- Industrial/Commercial/Institutional Incinerators

In the first four of these industrial classes, sulfur contained in raw materials is released when materials are heated to high temperatures during a manufacturing process. Emissions from sewage treatment plants and incinerators are the by-products of a waste disposal process.

The magnitude of miscellaneous process emissions is thought to have been fairly constant over the three years of interest, as shown in Figure A2.20. The annual average spatial distribution of these industrial process emissions is shown in Figure A2.21 for the year 1973 for sources located within the 50 by 50 mile grid. There are, however, a number of major off-grid metals and minerals processing SO_x emissions sources, as can be seen by reviewing emissions data for off-grid sources given in Tables A2.14 through A2.16 in the summary to this appendix.

A2.5.1 Petroleum Coke Calcining Kilns

Coke calcining kilns are by far the largest source of SO_x emissions from miscellaneous industrial processes within the 50 by 50 mile grid. Petroleum coke produced at local oil refineries is calcined in five large rotary kilns in the Los Angeles harbor area. The input coke to these kilns is a solid made from the highest

SOX EMISSIONS FROM MISCELLANEOUS STATIONARY SOURCES (SHADED)

VS. TOTAL SOX EMISSIONS WITHIN THE 50 BY 50 MILE SQUARE

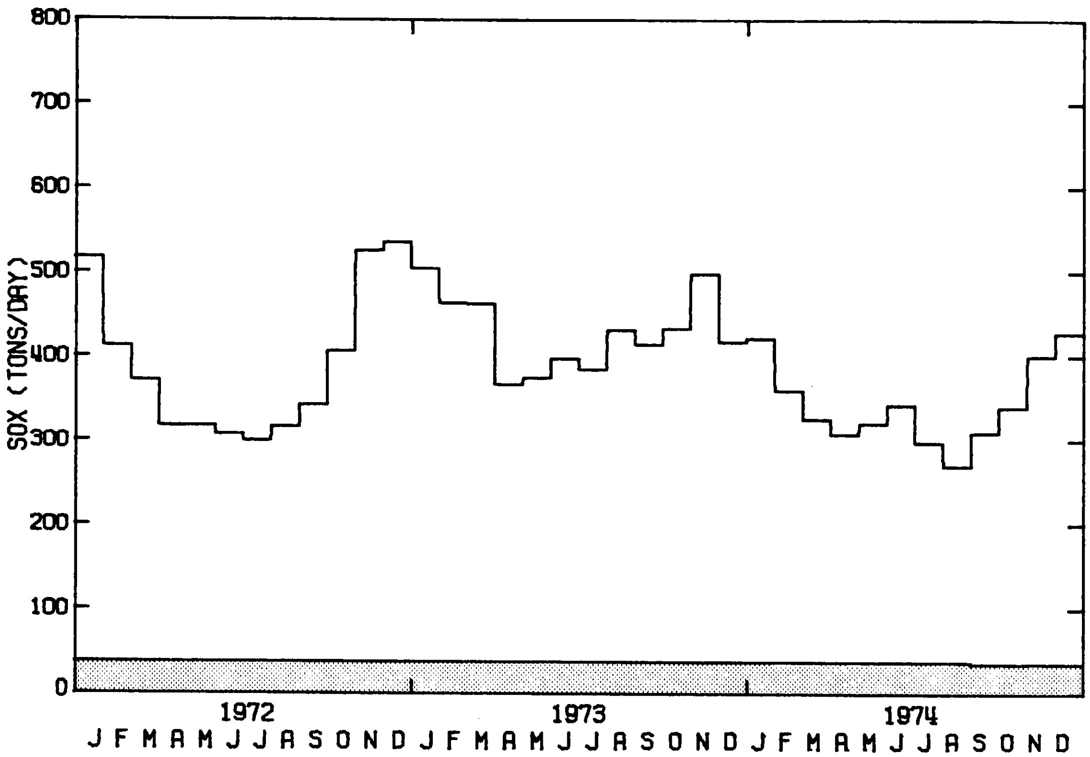


FIGURE A2.20

MISC INDUSTRIAL PROCESS EMISSIONS FOR 1973 IN TONS PER DAY OF SOX STATED AS SO2

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
24	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21	0.0	0.0	0.0	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0	0.0	0.02	0.0	0.0	0.0	0.0
19	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.02	0.0	0.0	0.0	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0	0.0	0.0
18	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.06	0.00	0.0	0.0	0.0	0.0	0.19	0.0	0.00	0.0	0.0	0.0	0.0	0.00
17	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.04
16	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0	0.0	0.0	0.09	3.06	0.0	0.0	0.00	0.0	0.0	5.61	0.0	0.0	0.0	0.02	0.0	0.0
15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.51	0.39	0.0	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14	0.0	0.0	0.0	0.0	0.0	0.00	0.0	0.00	0.02	0.0	0.0	0.22	0.00	0.00	0.0	0.0	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13	0.0	0.0	0.0	0.0	0.0	0.0	0.10	0.0	0.00	0.0	0.0	0.0	0.0	0.0	0.02	0.0	0.00	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0.0
12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.00	0.01	0.00	0.0	0.00	0.00	0.0	0.0	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0	0.00	0.00	0.0	0.0	0.00	0.0	0.0	0.13	0.0	0.0	0.0	0.0	0.0
10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.01	7.49	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18.03	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.00	0.0	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.42	0.0	0.0
5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.18	0.0	0.0	0.0	0.0
4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.35	0.0	0.0	0.0	0.0	0.0
2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

SOX
TONS/DAY
37.040

FIGURE A2.21

sulfur portions of the crude oil arriving at the refineries. As the coke is heated in these kilns, coke dust becomes entrained in the exhaust gases and is burned releasing bound sulfur as SO_2 or SO_3. SO_x emissions from these sources were inventoried at 25.5 tons per day for each year based on data presented by Hunter and Helgeson (1976). Due to their extremely high exhaust gas temperatures, coke calcining kilns have the highest fraction SO_3 in their exhaust and the highest average effective stack height of all major sources in the air basin.

A2.5.2 Glass Furnaces

There are 26 glass furnaces at 13 locations itemized within this emissions inventory. Twenty-two of these furnaces are located within the 50 by 50 mile grid. Emissions from all but two of these furnaces were based on APCD source tests or permit file emissions estimates. Emissions from furnaces at Glass Containers Corp. were estimated from KVB source test data (Hunter and Helgeson, 1976). Source tests selected in determining emission rates were all conducted while the furnaces were heated with either natural gas or electricity; any emissions from fuel oil combustion were inventoried in the fuel burning section of this report. Sulfur oxides emissions given here derive from fluxes (Na_2SO_4 or $BaSO_4$) used in the glass batch or from coloring agents (for example, iron pyrites) added to the glass. Estimates made largely from APCD data indicate that all glass furnaces together emitted about 2.0 tons per day of SO_x in recent years within the 50 by 50 mile square, and 2.23 tons per day within the entire air basin. Basin-wide glass furnace emissions of 2.15 tons per day were estimated by Hunter and Helgeson (1976). While agreement between these two data bases seems close, the APCD staff cautions us that glass furnace emissions are very erratic and change widely from one source test to the next, even under seemingly identical furnace operating conditions (Simon, 1976).

A2.5.3 Metals Processing Plants

Metals processing plant emissions totaled about 8.76 tons per day within the 50 by 50 mile grid during 1973. These sources include secondary lead smelters, brass furnaces and ferrous metals melting furnaces. Off-grid metal processing emissions are much larger, however, because of the need to include emissions from Kaiser Steel located in Fontana.

Secondary lead smelters are engaged in recovering lead from the plates of discarded automobile batteries. These batteries contained sulfuric acid. Sulfur compounds retained on the battery plates are emitted to the atmosphere when the plates are remelted. This inventory contains estimates for five secondary lead melting furnaces with combined SO_x emission rates averaging 8.67 tons per day during the years of interest.

Permit file emissions estimates for the five large lead furnaces were discarded, and emissions estimates were made from APCD source test data by an APCD engineer assigned to one of the sources (Menkus, 1976). A number of small lead sweating furnaces and melting pots originally assigned significant emissions rates in the APCD permit file were determined by discussion with APCD staff engineers to have negligible SO_x emissions rates. These smaller devices were dropped from the inventory.

SO_x emissions from other on-grid melting furnaces originate almost entirely from the fuel being burned to heat the furnaces. Fuel burning at on-grid steel mills has already been included in the industrial fuel burning inventory.

The principal off-grid metals processing plant is Kaiser Steel, located in Fontana in San Bernardino County. Emissions estimates for Kaiser Steel are available from the Southern California Air Pollution Control District (1976b), from Hunter and Helgeson (1976), and from the steel mill's staff (Smith, 1976). Discussions with Kaiser personnel indicate that this steel mill's SO_x emissions are directly proportional to the percentage of full capacity at which the mill is being operated. Therefore, in this inventory we have used total plant emissions rates calculated from Kaiser steel mill average capacity utilization in each year applied to Hunter and Helgeson's emission inventory estimates for 1974. The relative split in emissions between process types will be taken in proportion to Hunter and Helgeson's itemization in Table A2.10.

It should be noted that most of this steel mill's SO_x emissions result from fuel burning activities, including combustion of coke oven gas and blast furnace gas. These fuel burning emissions are itemized here because our spatially resolved industrial fuel burning survey did not extend beyond the borders of the 50 by 50 mile square.

TABLE A2.10

Estimation of SO_x Emissions from Kaiser Steel Mill In Fontana, California

Device	Number of Devices	SO_x Emissions (tons per average day) (YEAR) 1974[b]	1973[c]	1972[c]
Coke Ovens	7	6.93	7.54	6.40
Steel Furnace (burning coke oven gas)	13	12.60	13.71	11.63
Sinter Machine	2	4.37	4.75	4.04
Open Hearth Furnaces	8(a)	5.33[a]	5.80	4.92
Blast Furnace	4	1.12	1.22	1.03
Boilers	7	7.67	8.34	7.08
TOTAL EMISSIONS		38.02(d)	41.36	35.10

Notes:

(a) Estimated from Hunter and Helgeson (1976) after subtraction of four open hearth furnaces at U.S. Steel with FY74-75 SO_x emissions of 0.14 tons/day (Southern California Air Pollution Control District, 1976b).

(b) From Hunter and Helgeson (1976).

(c) According to Kaiser staff (Smith, 1976), emissions are proportioned to utilization of mill capacity.

Year	Mill Capacity Utilization
1972	84%
1973	99%
1974	91%

Therefore, Hunter and Helgeson's emissions estimates were scaled to preceeding years on the basis of changes in mill capacity utilization.

(d) The Southern California Air Pollution Control District (1976b) places FY74-75 Kaiser Steel emissions at 37.36 tons per day. However, emissions estimates provided by Kaiser staff (Smith, 1976) for 46 days in 1975 averaged 24.02 tons/day during a period when the mill operated at 75% of capacity. By that data set, full capacity emissions would be 32 tons/day. The reason for the emission estimate disagreement is not known.

A2.5.4 Mineral Processing Plants

Excluding glass furnaces which were inventoried separately, there are no major mineral processing SO_x emissions sources located within the 50 by 50 mile square grid. Two off-grid sources will be inventoried as shown in Table A2.11. Crestlite is engaged in manufacturing of lightweight aggregate, while the other source's line of work speaks for itself. There are several cement kilns located beyond the borders of the 50 by 50 mile square. Emissions inventories available from the Southern California Air Pollution Control District (1976b) and from Hunter and Helgeson (1976) indicate that virtually all of the SO_x formed during fuel combustion is removed by the lime being formed in these cement kilns. Cement plant SO_x emissions appear to be negligible and were dropped from this inventory in order to reduce the number of off-grid sources considered.

A2.5.5 Miscellaneous Industrial Processes

There are 42 items of industrial process equipment within the 50 by 50 mile grid remaining in the APCD permit file with SO_x emissions too small to have warranted a separate discussion of their mode of operation. Emissions from these sources totaled about 0.23 tons per day. With one exception, permit file emissions for such sources were accumulated to the grid system without further screening. One brake shoe debonder with fairly substantial permit file emissions was tested by Hunter and Helgeson (1976) and found to have negligible SO_x emissions. This source was deleted from our files.

TABLE A2.11

Itemization of Non-Utility Off-Grid Sources Included Within the Air Quality Modeling Emission Inventory

Stationary Source Type	Grid Square Location East/West I	Grid Square Location North/South J	Emission Rate (tons/day SO_x) 1972	Emission Rate (tons/day SO_x) 1973	Emission Rate (tons/day SO_x) 1974
Glass Furnaces					
Thatcher Glass	04	30	0.124[a]	0.124[a]	0.124[a]
Brockway Glass	26	17	0.103[a]	0.103[a]	0.103[a]
Metals Industries					
Kaiser Steel	33	18	35.10[b]	41.36[b]	38.02[b]
Ameron Steel	32	19	0.10[c]	0.10[c]	0.10[c]
Mineral Products					
Crestlite	29	-3	1.40[d]	1.00[d]	1.00[e]
Rockwool	33	18	0.90[c]	0.90[c]	0.90[c]

References:

(a) Southern California Air Pollution Control District permit file.

(b) See Table A2.10.

(c) Southern California Air Pollution Control District (1976b).

(d) Kaye (1976).

(e) Hunter and Helgeson (1976).